THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. X.

No. XI.—NOVEMBER, 1893.

ORIGINAL ARTICLES.

I.—Restoration of *Coryphodon*.

By Professor O. C. Marsh, M.A., Ph.D., LL.D., F.G.S., Etc.

(PLATE XVIII.)

THE genus *Coryphodon*, established by Owen in 1846, is of great importance alike to geologists and palæontologists. It represents a remarkable group of large ungulate mammals now known to have lived both in America and Europe during early Eocene time. The remains are found in a distinct horizon, essentially the same in each continent. This horizon is so well marked that geologists may use it as a base for determining the age of other strata. The Coryphodont mammals themselves are of special interest to anatomists, owing to the primitive characters shown in the skeleton. Perhaps their greatest importance lies in the fact, that these large hoofed mammals make their appearance suddenly in great numbers at the base of the Tertiary, without a hint as to their ancestral line, and with only diminutive generalized forms for their Mesozoic predecessors.

In Europe, Coryphodont remains, especially teeth, have been known under various names since the time of Cuvier, the first specimen, a molar tooth, having been found in 1807. All the remains since discovered there have likewise been fragmentary, and descriptions of them will be found in the works of Owen, Hébert, de Blainville, and more recent authors. A summary of the literature is given in the Palæontology of von Zittel, Volume IV. now in the press.

The first specimen of *Coryphodon* discovered in America was found in 1871, near Evanstone, Wyoming, by William Cleburne, while engaged as surveyor for the Union Pacific Railroad. He secured various remains, chiefly teeth and vertebræ, which were found together, and apparently belonged to a single individual. Some of these specimens he gave the same year to Prof. F. V. Hayden for transmission to Dr Joseph Leidy, who failed to receive them. They were subsequently described by Prof. E. D. Cope under the new generic names *Bathmodon* and *Loxolophodon*.[1] Portions of the same skeleton, including both teeth and vertebræ, were later given to the writer by Mr. Cleburne, and with them the above statement of

[1] Proc. Amer. Philos. Soc. vol. xii. pp. 417 and 420, 1872.

the discovery and disposition of the specimens found. Prof. Cop in 1872, gave the name *Metalophon* to a specimen from anoth locality in Wyoming, and subsequently (1873–1875), in sever papers, and under the above generic names, described vario remains from Wyoming and New Mexico. He also gave figur of a molar tooth, the hind foot, and a skull, all of which he referr to his genus *Bathmodon*.

In the meantime, the writer had been investigating remains the same group from Wyoming and New Mexico, including portio of the original specimen found by Mr. Cleburne, and other materi of much interest. It was soon ascertained (1) that all these remai were apparently identical with those of the genus *Coryphodo* Owen, as described and figured by him and Hébert;[1] and (2) th the geological horizon of these fossils was essentially the same bot in America and Europe. An investigation was made of the skul and especially of its brain-cavity, the latter indicating a brain very inferior type. The feet proved to be of a primitive form, th manus and pes each having five very short functional digits. Th remains studied belonged to a new family, named by the writer th *Coryphodontidæ*. These and other results were brought together i a paper entitled "On some Characters of the genus *Coryphodo* Owen," and in it were given figures of the skull and the brai cavity of a new species, *Coryphodon hamatus*. This paper wa published separately, April 15th, 1876, and subsequently appeare in the American Journal of Science, vol. xi. p. 425, May, 1876.

Subsequent to the publication of these determinations by th writer, Prof. Cope admitted, in several papers, the reference of thes remains to the genus *Coryphodon*, and the identity of the horizon in this country and Europe in which they were found, but witho referring to the above article on the subject. He likewise describe in detail, and figured, in 1877, what he considered a brain-cast *Coryphodon*, but again without any reference to the paper in whic the year before, the writer had given accurate figures of the brai cast of that genus. In the specimen described by Prof. Cope, th cribriform plates of the brain-case were apparently wanting, so tha in the cast figured the olfactory lobes appear to extend far forward thus giving a wrong idea of the original brain.[2]

In the same year, 1877, the writer published a second articl under the title, "Principal Characters of the *Coryphodontidæ*," i which he gave more in detail a description of the skull and brai cast of *Coryphodon*, with a figure, and also the main facts in regard t the skeleton. The feet of this genus, before practically unknown were described and figured, and especially compared with those o *Dinoceras*, which were also represented for comparison.[3] In Woodcut Figs. 2 and 3, of the present article, the original figures of the feet o

[1] British Fossil Mammals and Birds, p. 299, 1846; and Annales des Science Naturelles, tome vi. p. 87, 1856.

[2] Proc. Amer. Philos. Soc. vol. xvi. p. 616, plates i–ii. 1877. See also Amer Naturalist, vol. xi. p. 312, and 375, 1877; and Nature, vol. xvii. p. 340, 1878.

[3] American Journal, vol. xiv. p. 81, plate iv. July, 1877.

Coryphodon, as given by the writer in 1877, are repeated. The original figure, also, of the skull and the brain-cast, given by the writer first in 1876, and again in 1877, is repeated below, Figure 1.

In another publication (American Journal, vol. xiv. p. 354, 1877) the writer defined more fully the horizon in the lower Eocene in which the *Coryphodontidæ* had been found in this country, and named the deposits the Coryphodon beds.

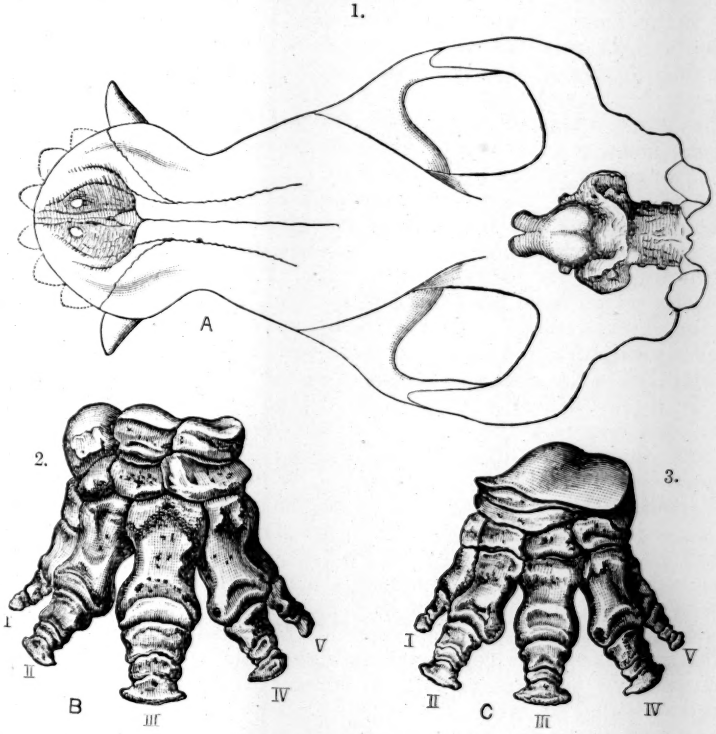


Fig. 1.—Outline of skull and brain-cavity of *Coryphodon hamatus*, Marsh; top view. About one-fifth natural size.
Fig. 2.—Fore foot of *Coryphodon*; front view.
Fig. 3.—Hind foot of *Coryphodon*; front view. Both one-third natural size.

The most important publication of Prof. Cope on the *Coryphodontidæ* will be found in vol. iv. of the Wheeler Survey, published in 1877. The remains of a number of different forms, mainly from New Mexico, are described and figured, and the relations of the group to some allied mammals are discussed. In the following year, Prof. Owen published again on *Coryphodon*, in the Annals and Magazine of Natural History (vol. ii. p. 216, 1878), giving figures of some American forms. In various papers, Prof. Cope subsequently referred to the *Coryphodontidæ*, naming several supposed

species and two genera, *Manteodon* and *Ectacodon*, but adding li
of importance to what was already known of the group. In
volume on "The Vertebrata of the Tertiary Formations of
West," 1884, he again discusses at length the *Coryphodontidæ*,
gives a number of new figures. The historical part, pp. 513–5
is marred by many errors, characteristic examples of which n
be seen in two footnotes, pp. 513 and 516. The statements th
made are erroneous, as has already been shown in the present arti

In his monograph on the *Dinocerata*, 1884, the writer discus
the various relations of the *Coryphodontidæ* to the *Dinocera*
giving figures of the skull and brain-cast, the upper and lo
molar teeth, and the feet, of *Coryphodon hamatus*. The na
Amblydactyla was substituted for *Amblypoda*, and *Coryphodontia*
Pantodonta, the names replaced both being essentially preoccupi

Two recent papers by Mr. Charles Earle, on the *Coryphodonti*
are of interest.[1] He treats of the teeth of this group, especially
their variations and homologies, and gives figures of some of t
most characteristic forms. He also discusses at length the vario
American species named, and decides "that the large number
species which have been founded by Prof. Cope should be great
reduced; and that in many cases his species are to be consider
merely varieties, and that often these varieties are merely individu
variations in the same species due to age and sex."

In a joint paper by Prof. H. F. Osborn and Dr. J. L. Wortma
which appears in the Bulletin of the American Museum, p. 8
1892, the former discusses this group briefly, especially son
specimens recently collected in the Wind River region by D
Wortman, and gives two figures of the feet of *Coryphodon*.
this paper, p. 118, the family *Coryphodontidæ*, established by th
writer in 1876, is credited to Prof. Cope, but with no referen
as authority, while the preoccupied names *Pantodonta* and *Ambl*
poda are also used in place of *Coryphodontia* and *Amblydactyla*.

In discussing the foot structure of *Coryphodon* (p. 121), Pro
Osborn makes some very emphatic statements, which are importa
if true, but he gives no facts to support them, and there is goo
evidence that he is in error. One statement is as follows: "th
positions of the fore and hind feet of *Coryphodon* were absolutel
different, the *fore foot was digitigrade* like that of the Elephan
and the *hind foot was plantigrade* like that of the Bear." Thes
positions are shown in his figures, which afford no evidence t
support the statement, especially in regard to the hind foo
Again, in giving the characters of the feet, Prof. Osborn adds t
what was already known, that the "second metacarpal" has
vertical ectocuneiform facet; a statement likewise open to questio
Another assertion (p. 122) nearly as strange is, that in "Th
figure of the pes of *Coryphodon* given by Marsh . . . . the astragalu
is represented as *covering the entire upper surface of the cuboid*.
A reference to the figure in question (fig. 3) will, however, sho

[1] Science, vol. xx. p. 7, 1892; and Bull. Amer. Mus. vol. iv. p. 149, 1892.

this statement, also, to be wrong, as the calcaneum covers about half the cuboid." This fact was clearly stated in the text when the figure was first published. The "unique caudal appendage" described by Prof. Osborn (p. 120), and the suggestion in regard to its use, do not require special notice here. The above points will be discussed later in the present article.

Restoration of Coryphodon hamatus.

After the above brief review of the more important literature relating to the Coryphodont mammals found in America, the main object of the present article, the restoration of one species of *Coryphodon*, may be considered. In Plate XVIII. this restoration is given one-twelfth natural size. The position shown was chosen after careful consideration, and is believed to represent fairly one naturally assumed by the animal in life, when standing at rest. The figure represents a fully adult individual of one of the largest species of the genus, which, when alive, was nearly six feet in length, and about three feet in height.

The basis of this restoration is the type specimen of *Coryphodon hamatus*, and this was supplemented by other remains which appeared to be specifically identical. A large number of such specimens were available, some of them in excellent preservation. For parts of the skeleton where such remains were wanting, specimens from nearly allied forms were used, but no serious error can thus result. In these remains, the caudal vertebræ were seldom preserved in good condition, and although a sufficient number of such specimens from different individuals were at hand, the exact number in the present species could not be determined, and hence the vertebræ of the tail are left in outline.

No clavicles are represented in the restoration, and no evidence of their existence has been found by the writer in the many remains investigated. The specimens described by Prof. Cope as clavicles of *Coryphodon* probably do not pertain to that genus. A bone very similar in shape to the supposed clavicles was figured by him as the fifth metatarsal, in the first diagram he published of the hind foot of *Coryphodon*. The same figure has three phalanges in the first digit, and the ectocuneiform supported mainly by the astragalus; features not seen elsewhere by the writer.

The feet of Coryphodon.

The structure and position of the feet of *Coryphodon*, as represented in the restoration, require some consideration in this connection, in view of differing opinions on these points. The fore feet of *Coryphodon* were first figured and described by the writer, and figure 2 is the original cut then published. This figure was made from a well-preserved specimen in which both fore feet were present, and nearly in position when found. They were carefully kept in the matrix until prepared for the drawing, and hence the accuracy of the figure cannot well be questioned. The fore feet represented in the present restoration are constructed mainly from

the same specimen, and the position given in the original figu has been essentially retained. The small size of the restoratio does not permit as accurate an exhibition of the structure of the fe as could be desired, but the main features are clearly shown. I this species, the pyramidal bone (cuneiform) touches the fifth met carpal, and helps to support it, as in *Dinoceras*, as already shown b the writer. This is the rule in adult individuals of *Coryphodo* but in young specimens the metacarpal facet on the pyramid may be indistinct or even wanting, as is sometimes the case wit weathered specimens.

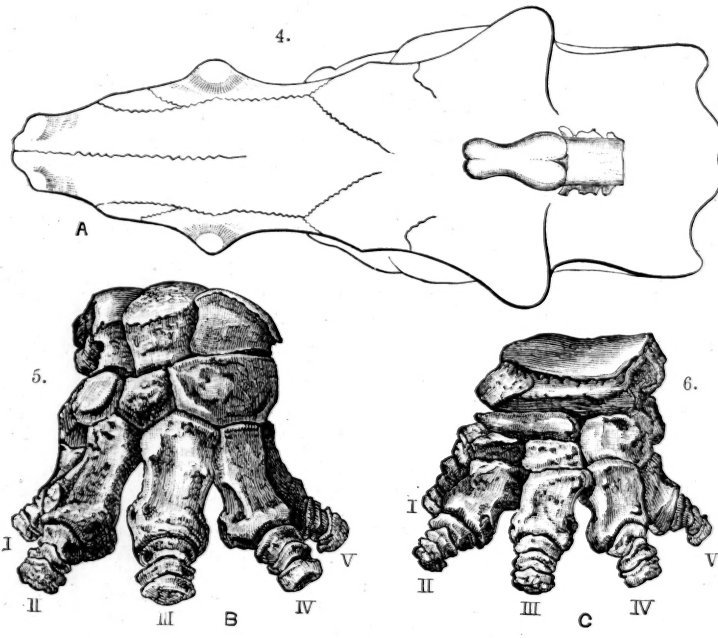
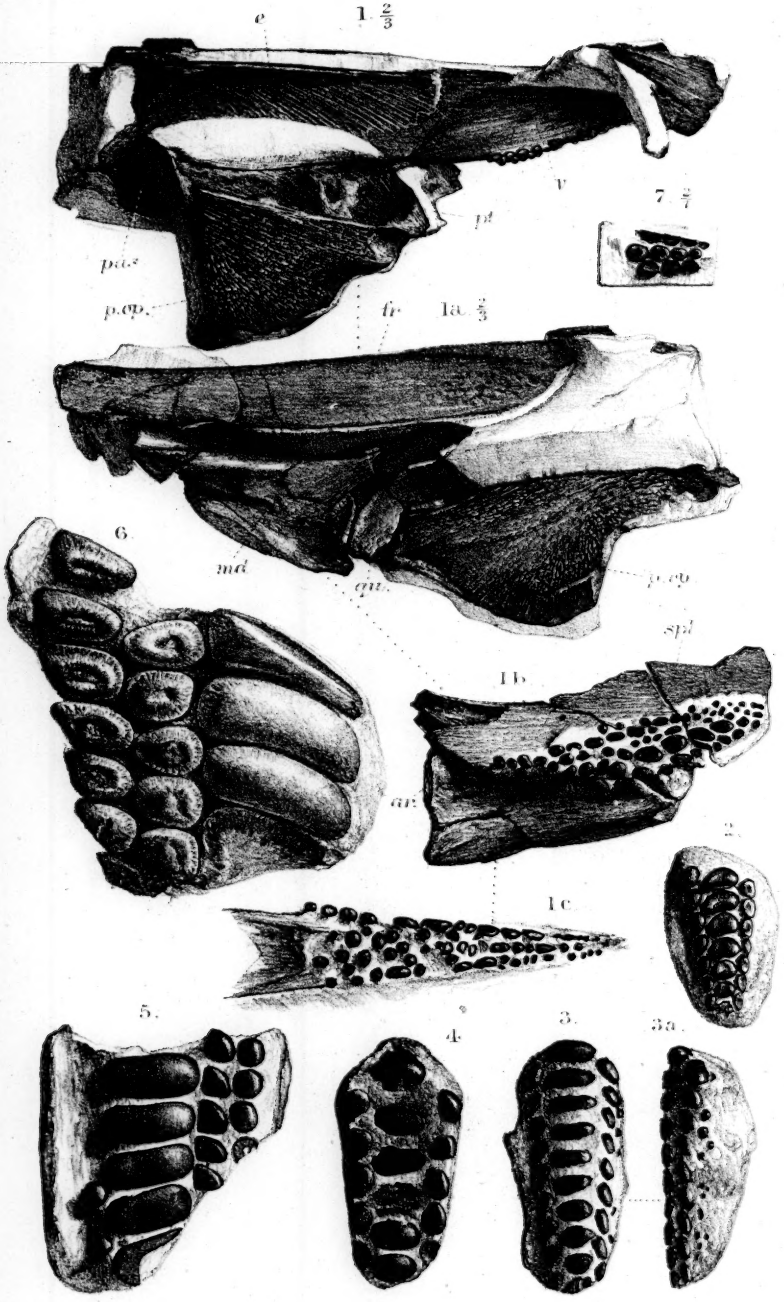


Fig. 4.—A. Frontal aspect of cranium of *Dinoceras* (Marsh).
Fig. 5.—Fore foot of *Dinoceras*; front view.
Fig. 6.—Hind foot of *Dinoceras*; front view. Both one-fifth natural size.

The hind feet of *Coryphodon* were investigated by the writer a the same time as the fore feet, and figure 3, of the left pes, wa published with figure 2, and is believed to be equally accurate Being a front view, it does not fully show the relations to each othe of the astragalus, calcaneum, and cuboid, but the other elements ar clearly exhibited. The position first given to the figure is retaine in the restoration after a careful investigation of the whole posterio limbs in a number of well-preserved specimens. These differ con siderably among themselves, but the essential structure is identica in all. The feet bones of some of these specimens are very perfect and their relations to each other cannot well be misinterpreted.



F.H.Michael del. et lith.

Mintern Bros. imp.

CRETACEOUS PYCNODONTS.

The above figures show the left fore and hind feet of *Coryphodon* and *Dinoceras* all seen from in front. The feet of the two genera as exhibited have many points in common, and their positions during life were probably nearly the same. The feet of *Coryphodon* are older in point of time. Those of *Dinoceras* are near to *Coryphodon* in their general structure, but the points of resemblance need not be enumerated here.

The existing Elephant, as well known, has all the toes of each foot enclosed in a common integument, but is really digitigrade. In *Dinoceras*, the terminal phalanges are much larger, showing that they themselves bore a greater weight, the digits being undoubtedly free, although a pad may have helped to support the foot. In *Coryphodon*, the digits were still more elongate, and the terminal halanges proportionately larger and broader, somewhat like those of the Rhinoceros, indicating that they were covered with hoofs that supported the feet. This would agree with the position given them in the restoration, which coincides with the anatomical structure of the entire hind limb.

II.—Some Cretaceous Pycnodont Fishes.

By A Smith Woodward, F.L.S., F.G.S.

(*Continued from page* 436.)

2.—On the Genus *Anomœodus*, with Remarks on the Structure of the Pycnodont Skull.

(PLATE XVII.)

THE only important fragment of a Pycnodont fish hitherto known from the English Cretaceous Formations, is the portion of head and trunk figured and briefly noticed by Dixon under the name of *Gyrodus angustus*, Ag.[1] This specimen displays the splenial bones from the oral aspect; some of the vertebral hæmapophyses; and thick scales with a reticulated ornament, covering only the anterior half of the trunk. The ventral ridge-scales also exhibit very conspicuous serrations. The splenial bones are imperfect, but sufficient to show all the essential characters of their oral face; and these elements present the only unique feature in the specimen. It will be observed that, whereas in all Pycnodont splenials hitherto described the dentition reaches the outer border at least in part of its extent, the bone in *Gyrodus angustus* has a wide toothless outer margin and an attenuated knife-like edge. The two vacuities in this margin shown in Dixon's figure are partly due to accident, partly imaginary, and there is no doubt that the bone forms a continuous whole.

Now, it is obvious from the specimen just described, that the fish in question cannot be assigned to the genus *Gyrodus*; for it differs both in the arrangement of the teeth and in the absence of scales

[1] F. Dixon, "Geology and Fossils of Sussex" (1850), p. 370, pl. xxxiii. fig. 1. See also Smith Woodward, Proc. Geol. Assoc. vol. x. (1888), p. 307.

upon the caudal region. It has thus been suggested[1] that the species might be more appropriately placed in the typically-Cretaceous genus *Cœlodus*; and at the same time it has been recognized that there is no essential generic difference between the form of dentition known as "*Gyrodus angustus*" and that from Maastricht, described by Agassiz, under the name of *Pycnodus subclavatus*. No splenial bones of the latter have hitherto been discovered sufficiently well preserved to show whether or not they possess the toothless border so characteristic of the species from Sussex; but if any reliance can be placed upon the agreement in the arrangement of the teeth the generic identity of the species *G. angustus* and *P. subclavatus* may be determined with as much certainty as can be attained in the classification of fragmentary Pycnodont remains.

To decide upon the accuracy of this identification or otherwise is important, because six years ago the dentition commonly known as *Pycnodus subclavatus* was described by Forir[2] as indicating a previously unrecognized distinct genus, *Anomœodus*; and the sole definition was based upon the arrangement of the splenial teeth. If, now, the universal belief that "*Gyrodus angustus*" and "*Pycnodus subclavatus*" are generically identical, be correct, new evidence is forthcoming to render the definition more satisfactory. So far as the arrangement of the splenial teeth in *Anomœodus* is concerned, there is no essential point to distinguish it from the Jurassic genus *Mesodon*; but on examining the attached face of the bone (e.g. *A. superbus*, Pl. XVI. Fig. 5*a*), the form will be seen to be quite different from that of *Mesodon* (Pl. XVI. Fig. 6), the first being shaped as in *Pycnodus* with a single sharp ridge curving to the postero-external angle, the second having a broad, longitudinally-grooved ridge not so sharply turned outwards. As regards the comparison with *Cœlodus*, it may be remarked that the difference in the arrangement of the splenial teeth is too great to render generic identity probable.

We therefore assume that the provisional arrangement adopted by Forir will eventually prove correct, and that the characters of the splenial bone, now known only in two British Cretaceous species, will be shown by later discoveries to be common to the others. On this assumption the following preliminary diagnosis may be hazarded:—

Genus Anomœodus.

Head-bones ornamented with reticulating rugæ; the smaller teeth usually with an apical indent, the principal teeth quite smooth or with a very feeble linear indent. Vomerine teeth in from three to five longitudinal series; splenial dentition restricted to a space considerably separated throughout its extent from the thin oral border of the bone, comprising one principal series of teeth, flanked within by at least one small series and outside by two or more small series. Scales robust, confined to the anterior part of the trunk in advance of the median fins, and ornamented with reticulating rugæ.

[1] K. A. von Zittel, "Handbuch der Palæontologie," vol. iii. (1887), p. 249.

[2] H. Forir, "Contributions à l'Etude du système Crétacé de la Belgique," Ann. Soc. Géol. Belg. vol. xiv. (1887), Mém. p. 25. Also *ibid.* vol. xvi. Mém. p. 445.

The fragments of Pycnodont dentition to be provisionally grouped under this generic name are numerous and widely distributed in the Cretaceous formations of Europe, and comprise, among others, the fossils named *Pycnodus subclavatus*, *P. Muensteri*, and *P. cretaceus* by Agassiz. On the present occasion, however, it is not proposed to refer to more than two new forms; an attempted revision of the whole subject being deferred to the forthcoming Part III. of the British Museum Catalogue of Fossil Fishes. One of these new forms is a common fossil in the Cambridge Greensand; the other is represented by a fine specimen in the Brighton Museum, from the Sussex Chalk, affording much information concerning the structure of the Pycnodont skull. For the opportunity of studying the finest examples of the first-named species the writer is indebted to Prof. McKenny Hughes and Henry Woods, Esq; for the privilege of examining the second to Henry Willett, Esq., and to Edward Crane, Esq., Chairman of the Brighton Museum Committee.

ANOMŒODUS SUPERBUS, sp. nov. Plate XVI. Figs. 5, 5*a*.

Type. Left splenial; Woodwardian Museum, Cambridge.

A large species known only by the splenial dentition. Teeth of the principal series on the splenial bone slightly arcuated, somewhat tapering and turned forwards at the inner extremity, attaining a breadth more than three times as great as their length; inner teeth in two series, those of the one adjoining the principal teeth large and irregular in form, usually with long axis oblique, and those of the innermost row small and rounded; flanking teeth in three series, smooth, diminishing outwards and all smaller than the large series of inner teeth.

This is one of the commonest forms of Pycnodont dentition in the Cambridge Greensand, and the finest known specimen is shown from the oral aspect in Plate XVI. Fig. 5, from the inferior side in Fig. 5*a*.

Form. and Loc.—Cenomanian; Cambridgeshire.

ANOMŒODUS WILLETTI, sp. nov. Plate XVII. Figs. 1, *a–c*.

Type. Imperfect skull, with dentition; Brighton Museum.

A small species, with teeth very irregularly arranged. Teeth of the principal series on the splenial bone obliquely set, very irregular in size and shape, wide mesially, tapering at each extremity, and not much broader than long; inner teeth relatively large in one series, usually broader than long with axis oblique; outer teeth in about three very irregular series, mostly smaller than the teeth of the inner series. Vomerine dentition anteriorly in three series, posteriorly in five, but extremely irregular; the largest teeth much antero-posteriorly elongated and comprised in the outermost series. Nearly all the teeth indented, the smaller ones having the pit especially conspicuous and surrounded with a crenulated margin.

The type specimen in the Willett Collection, Brighton Museum, exhibits the antorbital portion of the skull with the left mandibular

ramus, and was obtained from the Lower Chalk of Glynde, Sussex. It is shown in side view, of two-thirds the natural size, in Plate XVII. Figs. 1, 1*a*; while the splenial and vomerine dentitions are represented of the natural size in Figs. 1*b*, 1*c*.

The skull is much elongated, and the snout must have been acutely pointed. The median septum in the rostral region is robust, with a slight horizontal expansion at its upper edge; and the limits of the ethmoidal bone (*e.*) are indicated by the fact that its structural fibres are directed downwards and forwards, while those of the vomer (*v.*) are horizontal. The vomer appears to have been single, and bears teeth, as already described (Fig. 1*c*). Of the cranial roof only one bone is preserved, a long smooth element on the left side (Fig. 1*a*, *fr.*), evidently to be regarded as frontal.

At the hinder extremity of the vomer, a short distance beyond the limit of the dentition, there is seen the pterygo-quadrate-palatine arcade (Fig. 1, *pt.*); and throughout the length preserved, this is shown to form a continuous, inwardly-curved thin plate fused with the base of the skull (perhaps with the edge of the parasphenoid). The posterior part of the fossil also exhibits a thin median plate (Fig. 1, *pas.*) descending from the inferior face of the parasphenoid. The constituents of the pterygo-palatine arcade cannot be distinguished; but its anterior thickened margin, with a re-entering angle, is shown on the right side (Fig. 1), and the robust quadrate articulation, much deeper than broad, with its hollowed facette for the attachment of the mandible, is preserved on the left (Fig. 1*a*, *qu.*). To the postero-external border of the quadrate and its supporting bones on each side, there is also firmly fixed an outer element, with rugose surface, much expanded below and contracted above, which evidently occupies the situation of a pre-operculum (*p. op.*). Its correct shape is shown on the left side (Fig. 1*a*, *p. op.*), and this seems to be the bone already described in *Gyrodus* as "maxilla."[1] The imperfect mandible is also shown, a fragment of the right ramus being displaced to the extremity of the snout (Fig. 1), and the left ramus being nearly complete, though much fractured (Fig. 1*a*, *md.*, Fig. 1*b*.). The structure of the mandible is not clear; but the articular element (Fig. 1*b*, *ar.*) exhibits a very deep undulating facette, and on the splenial (*spl.*) the dentition appears to be restricted to a surface considerably within the external margin of the bone.

Between the two jaws there are also remains of stout bones, perhaps of the hyoid arch, but these are insufficient for determination.

To summarize, the skull of *Anomœodus Willetti* shows that (i) the vomer is single; (ii) the mandibular suspensorium is strongly inclined forwards; (iii) the pterygo-palatine arcade is delicate, toothless, and fused throughout the greater part of its length with the base of the skull; (iv) the parasphenoid has a deep inferior lamellar keel; (v) the articulation of the mandible is very deep and narrow; and (vi) there is a large superficial bone apparently

[1] A. Wagner, Abhandl. k. bay. Akad. Wiss., math.-phys. Cl., vol. ix. (1862), p. 326. Also K. A. von Zittel, "Handb. Palæont." vol. iii. (1887), p. 239, fig. 251.

to be identified with the pre-operculum. On comparing the arrangement with the skulls of recent fishes no closer parallel can be found than in some of the Plectognathi, where the specialization seems to be much of the same character. Whether, however, the agreement be a real proof of close affinity, or whether it be merely a case of similar mechanical conditions leading to analogous modifications, cannot be determined until the osteology of all the principal Pycnodont genera has been investigated.

Form. and Loc.—Turonian; Sussex.

3. Description of the Splenial Dentition of two New Species of *Cœlodus*.

There still remains much fragmentary evidence of species of *Cœlodus* hitherto unrecognized, and it seems advisable to propose specific names for the two well-marked new forms of splenial dentition described below. The specimen from the Chalk is as yet unique, and but few examples of the Cambridge Greensand fossil have come under the writer's notice.

Cœlodus inæquidens, sp. nov. Plate XVII. Fig. 5.

Type. Left splenial, with dentition; British Museum.

A species of moderate size, known only by the splenial dentition. Teeth of principal series attaining a breadth somewhat more than twice as great as their length, and exceeding in width the two flanking series, of which the inner teeth slightly exceed the outer in size, all being about as broad as long; a row within the principal series represented by few minute round teeth; all the teeth smooth.

This species is noteworthy for the smoothness and relatively small size of the two flanking series of teeth on the splenial bone.

Form. and Loc.—Cenomanian; Cambridgeshire.

Cœlodus fimbriatus, sp. nov. Plate XVII. Fig. 6.

Type. Imperfect right splenial dentition; British Museum.

A large species, known only by the splenial dentition. Teeth of principal series on the splenial bone smooth or feebly crimped round the margin, somewhat less than three times as broad as long, about equalling in width the two outer series, which are nearly similar in size, irregular in form, slightly broader than long, and have a deep coronal pit with rugose or crimped margin.

The type and only known specimen shown of the natural size in Pl. XVII. Fig. 6, was obtained from the Lower Chalk of Halling, Kent.

Form. and Loc.—Turonian; Kent.

4.—Some Undetermined Specimens of the Vomerine Dentition.

Among Cretaceous Pycnodonts there is a general tendency for the dentigerous face of the vomer to become narrowed and convex in transverse section; while three series of teeth are alone well developed, the outer flanking series being usually very small and

placed quite on the side of the bone. There is, however, as yet no means of distinguishing the vomer of *Cœlodus* from that of *Anomœodus*; and none of the detached specimens hitherto discovered can be referred with certainty to the species named from the evidence of lower jaws.

In recording some new examples of the vomerine dentition from Cretaceous rocks, it is therefore inadvisable to attempt their specific and generic determination; and we merely give the accompanying figures of four well-marked types (Plate XVII. Figs. 2-4, 7) without names. The original of Fig. 2, in the British Museum, was obtained from the Greensand of the Isle of Wight, and comprises three series of tumid, faintly indented teeth almost in one plane, with a very minute outer series well on each side of the bone. The originals of Figs. 3 and 4, in the Woodwardian Museum, are from the Cambridge Greensand: the first is remarkable for the relatively great width of the median teeth and the convexity of the dentigerous face (best observed in side-view, Fig. 3*a*), while the second is noteworthy for the flatness of the grinding surface formed by the three principal series of teeth.

Most interesting of all, however, is the small vomerine dentition from the Chalk of Charing, Kent, shown of twice the natural size in Fig. 7—a form represented in the British Museum by still another larger specimen from the Chalk of Southeram, Sussex. The worn teeth are coarsely punctate, and all seem to have been obtusely conical, though sometimes with an apical indent. Similar detached teeth have already been found in the Chalk of Bohemia and Saxony, and described under the name of *Pycnodus scrobiculatus*[1]; while portions of the vomerine dentition exactly similar to those now made known from the English Chalk have been described and figured by Geinitz[2] from the Turonian of the valley of the Elbe. Nothing is known of the true generic relationships of the fossils, and they may thus at present remain under the provisional name originally proposed by Reuss.

EXPLANATION OF PLATES.

PLATE XVI.

Fig. 1.—*Athrodon intermedius*, sp. nov.; left splenial dentition. Purbeck Beds; Aylesbury. [British Museum, No. 40314.]

,, 2.—*Athrodon tenuis*, sp. nov.; right splenial, from the oral, inner (2*a*), and inferior (2*b*) aspects. Lower Senonian; Lonzée, near Gembloux, Belgium. [Royal Museum, Brussels.]

,, 3.—*Athrodon crassus*, sp. nov.; right splenial, from the oral, inner (3*a*), and inferior (3*b*), aspects. Cambridge Greensand; Cambridge. [Woodwardian Museum, Cambridge.]

,, 4.—*Athrodon*, sp.; vomerine dentition. *Ibid.* [Woodwardian Museum.]

,, 5.—*Anomœodus superbus*, sp. nov.; left splenial, oral and inferior (5*a*) aspects. *Ibid.* [Woodwardian Museum.]

,, 6.—*Mesodon Damoni*, A. S. Woodward; left splenial, inferior aspect. Portland Stone; Weymouth. [British Museum, No. P. 6165.]

[1] A. E. Reuss, "Versteinerungen der böhmischen Kreideformation" (1845), p. 10, pl. iv. figs. 15–25, 64.

[2] H. B. Geinitz, Palæontogr. vol. xx. pt. i. (1875), p. 301, pl. lxv. figs. 31, 32.

PLATE XVII.

FIG. 1.—*Anomœodus Willetti*, sp. nov.; anterior portion of skull, viewed from the right and left (1*a*) sides, two-thirds nat. size. Also the left mandibular ramus, inner aspect (1*b*), and the dentigerous face of the vomer (1*c*). Lower Chalk; Glynde, Sussex. *ar.* articular; *e.* ethmoid; *fr.* frontal; *md.* left mandibular ramus; *p.op.* pre-operculum; *pas.* parasphenoid; *pt.* pterygo-palatine arcade; *qu.* quadrate; *spl.* splenial; *v.* vomer. [Willett Collection, Brighton Museum.]

,, 2.—Pycnodont Vomerine Dentition, oral aspect. Greensand; Isle of Wight. [British Museum, No. P. 3758.]

,, 3, 4.—Pycnodont Vomerine Dentition, oral aspect and side-view (3*a*). Cambridge Greensand; Cambridge. [Woodwardian Museum.]

,, 5.—*Cœlodus inæquidens*, sp. nov.; left splenial. *Ibid.* [British Museum, No. 36157.]

,, 6.—*Cœlodus fimbriatus*, sp. nov.; imperfect right splenial dentition. Lower Chalk; Halling, Kent. [British Museum, No. 43090.]

,, 7.—*Pycnodus scrobiculatus*, Reuss; vomerine dentition, twice nat. size. Chalk; Charing, Kent. [British Museum, No. P. 322.]

Unless otherwise stated the figures are of the natural size.

ERRATUM.—On page 435 the numbers of the figs. of *Athrodon crassus* and *A. tenuis* are transposed; *for* Fig. 2 *read* Fig. 3, and *vice-versâ*.

III.—On a Bed of Oolitic Iron-ore in the Lias of Raasay.[1]

By Horace B. Woodward, F.G.S.

[Communicated by permission of the Director-General of the Geological Survey.]

THE rocks of Raasay have attracted a good deal of attention from geologists, despite the fact that no house of public entertainment exists on the island. That portion of it which lies to the south of Brochel Castle, exhibits a base of Torridon Sandstone, above which there may be traced, more or less completely, in two faulted areas, an ascending series from the New Red rocks to the Great Oolite group. The Jurassic strata are finely exhibited in the eastern cliffs, but westwards they are largely covered by volcanic rocks, and especially by great sheets of Granophyre which descend in that direction to the sea-level. To the south-west there is a mass of Gabbro; in other parts there are sills and countless dykes of Basalt, while the summit of Dun Caan is formed of a bedded mass of that material. Coverings of Peat, of Boulder-Clay and Gravel, serve to add variety to the geology, and to obscure the outcrops of the Jurassic and other rocks.

Our knowledge of the geology is due principally to the labours of Macculloch and Murchison, followed by those of Sir Archibald Geikie, Dr. Bryce, Prof. Tate, and Prof. Judd.

Sir Archibald Geikie, in 1857, constructed a geological map of the island, on the Admiralty Chart, on the scale of about $2\frac{1}{3}$ inches to a mile, but this work has not been published, except in a very reduced form on geological maps of Scotland.

In the summer of last year, I commenced the mapping of the Jurassic rocks of Raasay for the Geological Survey, on the scale of

[1] Read before Section C, at the meeting of the British Association at Nottingham.

6 inches to a mile. In the end, I have had the satisfaction of finding my work in harmony with that of previous observers; and that the main features depicted on Sir Archibald's map coincided well with the stratigraphical divisions and faults I had traced, while working independently on the far better (though by no means perfect) sheets of the Ordnance Survey.

It will be needless to refer in detail to the observations published by others, as my object is simply to record the fact that during the course of my work I came across a bed of oolitic iron-ore that has not been previously noticed.

This iron-ore occurs in the uppermost part of the Middle Lias, on top of the calcareous sandstones that yield *Ammonites spinatus, Gryphæa cymbium, Pecten æquivalvis, Rhynchonella tetrahedra, Terebratula punctata,* and *Waldheimia cornuta*; and beneath the dark shales of the Upper Lias that yield *Ammonites communis, A. serpentinus, A. exaratus,* etc.

The ironstone itself yields fossils, but not in abundance, and too poorly preserved for specific identification. They include *Ammonites, Belemnites, Astarte, Pecten, Rhynchonella,* and pieces of fossilized wood. The iron-ore is a greenish-grey oolitic rock, weathering brown at the surface and along the joints; and it attains a thickness of five feet. Occasionally a thin layer of oolitic ironstone occurs above the main mass, near the base of the Upper Lias shales; and from this horizon I have obtained *Ammonites annulatus* and *A. communis.*[1]

The position of the Raasay ore therefore corresponds approximately with that of the Cleveland ironstone, although in Yorkshire the upper part of the Middle Lias contains a number of ironstone bands. Mr. George Barrow, to whom I showed a specimen of the Raasay ore, remarked that it precisely agreed with Yorkshire examples with which he is so familiar. In composition, as well as in other characters, the Raasay ore compares well with that of Cleveland, for analyses made by Mr. A. B. Dick show that they are practically identical. The Raasay ore yields 29 per cent. of metallic iron in the grey rock (carbonate), and 37 per cent. in the brown rock.

The iron-ore may be traced in several places on and near the footpath that leads from Loch a Mhuilinn, near Raasay Manse, towards Dun Caan, on the borders of the Inverarish Burn and its tributaries. It occurs near Macdonald's Glen, and some distance east of the main cascade, where the waters tumble over a mass of Granophyre that is faulted on the west against the Middle Lias. It may be traced for a mile at various points along this eastern outcrop; but further on towards Hallaig the strata are obscured by peaty coverings and *débris*, due to land-slipping. Again, the iron-ore may be found along the eastern slopes of Beinn na Leac, where the beds are much slipped, so that the true outcrop is almost wholly obscured. Nowhere along the grand cliffs below Dun Caan and onwards to Screapadal could I find any evidence of the iron-ore, nor was there

[1] The species of fossils collected by me were named by Messrs. G. Sharman and E. T. Newton.

any clear junction between the Middle and Upper Lias that was accessible. These cliffs rise in places, with an almost vertical face, to 800 or 900 feet; and if we include the higher steep slopes and the rough crag of Dun Caan, we have the somewhat dizzy height of 1455 feet. Hence the inaccessibility of the rocks in some places, and the landslips and tumbled blocks in others, render it impossible to follow everywhere the junction of Middle and Upper Lias. On this account it will be easily understood how the presence of the band of iron-ore escaped the notice of previous observers, who naturally devoted their chief attention to the coast-sections and to the strata displayed on the fore-shores. It was only by examining all exposures of the strata in banks and braes, and along the beds of burns, that I found the iron-ore *in situ*, and ascertained its persistence on the same horizon where the strata are exposed.

Dr. Bryce noticed the occurrence of "slightly ferruginous bands" in the Middle Lias, near Portree, in Skye; and he observed also, in the Upper Lias, a band of "nodular blue limestone, showing oolitic structure." These facts I can confirm from a general examination of the cliffs north and south of the entrance to Portree harbour; but I failed to find any evidence of a band of iron-ore equivalent to that of Raasay. The facts now brought forward, however, serve to strengthen the remarks of Dr. Bryce in reference to the Jurassic strata of Skye and Raasay, for he says: "The lithological characters of the beds have a remarkable similarity throughout, and a close resemblance to the structure of the beds on the Yorkshire coast."[1] I may add that I was greatly struck with the general similarity between the lithological characters of the several divisions of the Lias and underlying Red rocks in Raasay, and those familiar to me in the West of England; and among the fossiliferous rocks this similarity in lithology is accompanied by many identical organic remains. The Oolitic Series approximates more closely to the Yorkshire type.

IV.—The Recent Geological History of the Arctic Lands.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

SINCE writing my previous paper on the question of whether, during the so-called Glacial period, the Arctic lands had a milder and not a more severe climate, I have met with some evidence on the subject so important and suggestive that I feel sure it will be welcome to some of your readers, especially as it involves a considerable departure from conventional views. In 1861 Sir Joseph Hooker wrote his famous paper on the distribution of Arctic plants, in which he argued that the flora of Greenland is distinctly of European type; that Greenland is a sub-region, in fact, of the Scandinavian Botanical province. To state his own conclusion in his own words, "the flora of Greenland is almost exclusively Lapponian, having an extremely light admixture of American or Asiatic types." This view had already been maintained by Charles Martins in 1839, although he had not the same materials

[1] Quart. Journ. Geol. Soc. vol. xxix. p. 338.

to work upon. Speaking of the plants of Shetland, the Faroes, Iceland and Greenland, he says: "La migration européenne est évidemment prédominante." Hooker's view was supported by Blytt, who, writing in the Journal of Botany for 1887, says: "Even the Greenland flora consists principally of Scandinavian plants." Sir Joseph Hooker further concluded "that the existing Scandinavian flora is of great antiquity; that previous to the Glacial epoch it was more uniformly distributed over the Polar zone than it is now; that during the advent of the Glacial period the Scandinavian vegetation was driven southwards in every longitude, and even across the tropics into the south temperate zone; and that, on the succeeding warmth of the present epoch, those species that survived both, ascended the mountains of the warmer zones, and also returned northwards, accompanied by aborigines of the countries they had invaded during their southern migration." He further says: "If it be granted that the Polar area was once occupied by the Scandinavian flora, and that the cold of the Glacial epoch did drive this vegetation southwards, it is evident that the Greenland individuals, from being confined to a peninsula, would be exposed to very different conditions to those of the great continents. In Greenland many species would, as it were, be driven into the sea—that is, exterminated; and the survivors would be confined to the southern portion of the peninsula, and not being there brought into competition with other types, there could be no struggle for life among their progeny, and consequently no selection of better adapted varieties. On the return of heat these survivors would simply travel northwards, unaccompanied by the plants of any other country."

The general conclusion of Hooker and others about the affinities of the Greenland flora, and the widespread induction based upon it, have been recently sharply contested by two Scandinavian botanists. In 1880 Joh. Lange, in his "Conspectus Florae Grönlandicae," came to the conclusion that out of 386 species of Greenland plants 15 are endemic, 40 belong to the Western or American, and 44 to the Eastern or European district; that is to say, are otherwise only found in those districts; or, interpreting the facts most favourably to the Eastern side, there would be 36 Western as against 42 Eastern—a majority of six only in favour of the latter.

Some years later Warming subjected the botany of Greenland to a minute analysis and came virtually to the same opinion as Lange. He divides Greenland into two botanical provinces—a birch region (R. sub-Alpina) and an Alpine region (R. Alpina). The former is limited to the extreme south of Greenland, and is bounded by a line from Cape Farewell, 60° North lat. on the East coast, to about 62° on the west, and contains about 60 species of plants not otherwise found in Greenland. The other region includes all the rest of the country. His conclusion is, that while the former small district contains a considerable number of specially European types, the latter, viz. Greenland proper, contains hardly any; but does contain a number of American ones. The great bulk of the plants, however, of Greenland belong neither to Europe especially

nor to America, but are distinctly Circumpolar. Its 15 endemic plants consist of six species of *Carex*, three of *Potentilla*, *Epilobium ambiguum*, *Arabis Brentelii*, *Campanula grönlandica*, *Calamagrostis hyperborea*, *Glyceria Langeana*, *Poa filipes*.

Of the specially European plants, most of which are only found in the extreme south of the island, Warming considers that a large proportion have found their way there since Glacial times either by ocean currents, by being carried by birds, and in other ways. It would seem most certain, in view of his very careful analysis of the problem, that Hooker's original view can no longer be maintained and that Greenland cannot be treated as a section of the Scandinavian botanical province. Nor can we fairly treat it as a section of the North American botanical province either. On the contrary, it seems plain that it forms an integral part of what ought to be discriminated as a Pan-Arctic or Circumpolar botanical region.

This raises some very important questions and notably those connected with the Ice-age. The notion that the flora of Greenland was virtually exterminated by the Ice-age and has found its way thither again since that period must go to the wall, as Warming emphatically urges, and we cannot avoid his conclusion, that the present flora of Greenland outlived the so-called Glacial age there. Warming says further that Greenland during the Ice-age clearly had ice-free land. The many Danish geological and geographical expeditions which during the last ten years have visited the country have mapped it and described its geology and botany, and have made it plain that in S. Greenland, above the height of two to three thousand metres there is no mountain top showing any signs of former ice action. This would include several isolated mountains along the west coast, as far north as 70° of N. Latitude and a large part of the uplands of S. Greenland. Warming emphatically says there is no trace here of a general ice-covering, but only of local glaciers; it is here, he urges, that the plants we are discussing continued to live. Another similar vantage for them was in N.E. Greenland in the neighbourhood of Franz Josephs Fiord, where also there is evidence, that the land was not mantled with ice. Similar conditions also probably prevailed in Grinnell land, where Greeley, and about Discovery Bay in 82° 44′ North lat., where Nares found a comparatively rich vegetation with several very local species.

Warming further urges that the survival of the present fauna of Greenland from pre-Glacial times is also attested by the rarer plants. Putting aside South Greenland, where a considerable number of the plants may have been imported in post-Glacial times, the second German Polar Expedition found a number of plants in north-east Greenland such as *Polemonium humile*, *Arabis petræa*, *Saxifraga Hirculus* and *hieraciifolia*, *Draba altaica*, *Ranunculus glacialis*, etc., which are either not found elsewhere or in very few places. "It seems to me probable," says Warming, "that most of these, probably all, are to be numbered among the Autochthones." In north-west Greenland we find such rarities as *Pleuropogon Sabinei* and *Hesperis Pallasii*, which also probably outlived the ice period. *Androsace*

septentrionalis, which the Nares' Expedition found in Grinnell land, is there removed by a long distance from where it otherwise occurs. On the west coast are other rare plants, as *Ranunculus glacialis* south of Upernivik; *Eutrema Edwardsii* in latitude 70° 47′; *Taraxacum phymatocarpum* in 70°–74′ North latitude; *Utricularia minor* from 68°21′–69°, elsewhere it occurs in the Urals and the Altai. *Scirpus parvulus*, found in two places between 68° and 69° North lat., also European; *Cerastium arvense* found once in 67° 5′ North lat.; *Carex helvola*, also found in 67°, and also European; *Linnæa borealis*, found in 1883, near Ivigtut in 61° 10′ and in 1884 about 67°. *Arctostaphylos alpina*, sparingly between 70° and 65°; *A. uva ursi* only in one place, about 67° North lat. near Holstensborg; *Sisymbrium humile*, found in 1884 in the upper part of "Sondre Stromfjorde," in 66° 30′ North lat. Then among plants only found otherwise in America and West Siberia: *Gentiana tenella*, found in 1889; *Vahlodea atropurpurea*, *Andromeda polifolia*, *Rubus chamæmorus*, only found in Godhavn in 64° 10′ North lat. and several others. "The distribution of these plants," says Warming, "seems to me to point to their being relics of the old flora which have survived in favourable localities." He further argues that while some plants have managed to survive, others have succumbed, and notably such widespread genera as *Chrysosplenium* and *Caltha*, and also the various genera of *Oxytropis*, *Astragalus*, *Phaca*, etc., which are so widely spread in Alpine districts, and also in the Arctic regions, but are not found in Greenland. One of the most notable absentees from Greenland is the *Salix polaris*, which occurs in Spitzbergen, Scandinavia, North Russia, Siberia, and North America as far as Davis Straits.

These conclusions in regard to Greenland may be paralleled by those of Nathorst, in regard to Spitzbergen. He also concludes that the flora of that island, instead of being an importation since Glacial times, is really the wreck and ruin of what was once a much richer flora, and which has been able to survive the drastic conditions which now prevail there.

Warming argues that the specially European plants found in South Greenland are probably colonists from Iceland. In regard to Iceland itself it seems impossible to believe that its comparatively rich flora is the result of sporadic colonization. Long ago Pennant wrote, in his ingenuous way, that "there are found in Iceland 309 perfect and 233 cryptogamous plants, while on the Island of Ascension, which is totally and aboriginally volcanic, a flora of not more than seven plants is to be seen." This means that either Iceland has been connected with Europe by a land-bridge since Glacial times, or that its flora survived the Glacial age, which is much more probable.

Quite recently an examination of the flora which has appeared on the uncovered moraine of the great glacier in Alaska seems to point to the same lesson, while the instances of trees with their roots attached, which were found by Maclure and other Arctic navigators in the Arctic Archipelago of North America, seem to point also in the same direction. They all apparently converge upon one con-

clusion, namely, that if there has ever been a so-called Glacial period in the Arctic regions it is now. That the present period is *the* one period in their history when the reign of ice and snow has been dominant, that, so far as we can make out, their climate has been becoming more and more severe in historic times, and that in the Pleistocene age, so far as we have evidence, the climate of the Polar area was more and not less temperate than now. All this is completely at one with the more recent speculations of the zoologist, who sees in the Polar area the centre and focus of a geographical region, in which the animal forms are alike in all meridians, namely, the so-called circumpolar area, and who further argues that the two provinces which are known as Palæarctic and Nearctic, in so far as they are differentiated from each other, have become so very recently, and that in all probability they constituted in Pleistocene times one continuous and homogeneous district with the Arctic lands, a province marked by a similar fauna and flora. This again is confirmed by such facts as the occurrence of the great sea-cows which Steller discovered in Behring's Island, in a latitude far away from all their relatives and congeners. They are essentially animals which thrive under temperate or sub-tropical conditions, and this colony, so lately occurring in the North Pacific, seems to point very clearly to the climate of that region having been recently milder. The same conclusion as I have previously argued seems to follow, if we are to find any rational explanation of the problem of the northern migratory birds—birds which pass their summer in the Arctic and sub-Arctic lands and are scattered far and wide during the winter. Their types are so essentially northern that we can hardly doubt that at no remote time they were living all the year round in their present breeding quarters in Greenland and Spitzbergen, no less than in Northern Siberia. The cold which has deprived these birds of any suitable food and resting-place in the winter is the cold now prevailing, and not a much more severe cold dating from the Pleistocene age; and in explaining the difficulties and paradoxes of the distribution of animal life in the northern hemisphere, we must, as in the case of the vegetable life, invoke not a portentous period of ice in the last age of the world, but an increasing cold from the time of the Mammoth onwards and culminating in our own day. If this be so we may well advance another step and enquire what was the cause which has chiefly operated to bring about this result. Since it is one which is most potent at this moment, and which has been growing in intensity in historic times, it ought to be explained without appealing to transcendental causes, which are so easy to invoke, however hard they may be to justify, when we are dealing with a long-departed past.

In regard to Siberia, I have in previous papers endeavoured to offer an explanation of the problem as partially explained by the upheaval of the Tibetan plateau, and of the Himalayas and Altai, as Humboldt long ago argued, and partly by the stoppage of Behring Straits, which prevented the Polar current from reducing the temperature of Kamschatka and the Sea of Okhotsk.

In regard to Greenland, Spitzbergen, Iceland, and the Arctic Archipelago of America, etc., it seems impossible to disconnect the increasing severity of their climate with the contemporary and correlative gradual elevation of these northern lands above the sea-level. The fact is familiar enough in regard to some of them, and I myself in almost the first scientific paper I ever wrote, and published in the Journal of the Royal Geographical Society (since reprinted in the Arctic Manual), adduced a great deal of evidence on the subject to show that the area of current elevation in the Northern Hemisphere is continuous. Wherever the coasts of the northern lands have been examined (except only the southern extremity of Greenland, where the reverse seems to prevail) there is evidence of stranded Whales, drift timber, and of raised beaches, showing the very recent and continuing rise of the land.

This rise was necessarily concurrent with a corresponding alteration in climate, due to the accumulation of snow and ice above the snow line, the growth of glaciers and the dispersal of icebergs, and apart from the direct evidence already adduced it would have been possible and necessary to postulate such a change of climate, as a deduction from the fact of this recent elevation of the land alone. Here then we have a potent and efficient cause which is known to have been in active operation, and to which we can hardly fail to attribute the climatic changes above described. To shortly state the general conclusions which I would press :—

I. During the Pleistocene period the Arctic lands, instead of being overwhelmed by a glacial climate, were under comparatively mild conditions, and were the home of a widely spread and homogeneous fauna and flora constituting, perhaps, the best defined life-province in the world.

II. Since Pleistocene times the climate of these Arctic lands has been growing more and more severe, resulting in the extinction of a portion of their vegetable and animal inhabitants.

III. While one portion of this Pan-Arctic fauna and flora still remains largely homogeneous, another portion has become differentiated by evolution in Northern America and Northern Europasia, into the Nearctic and Palæarctic regions respectively.

IV. The true and the only Glacial climate which we know to have prevailed in the Arctic lands was not during the so-called Glacial age of geologists, that is during the Pleistocene period, but is that which is now current, and which is the product largely, if not entirely, of changes of level in the earth's crust which have occurred since Pleistocene times.

These conclusions, if sustained, ought to throw some light on the problem of finding a rational explanation of the Glacial phenomena of the temperate zones, and notably of North-eastern America and North-western Europe. I may, perhaps, be allowed to discuss this on another occasion.

I have to thank Mr. Howell for his very interesting letter, in which he supports my contention that there are no traces of former wide-spread ice-sheets in Iceland and only of local glaciers.

V.—The Geological Development, Descent and Distribution of the Mammalia.

By Prof. Karl A. von Zittel, Ph.D., For. Memb. Geol. Soc. Lond.;
Professor of Palæontology in the University of Munich.

(*Concluded from page* 468.)

Pliocene.

THE Pliocene mammalian land fauna lived at a period when Europe had already obtained the main features of its present configuration. Italy, to be sure, at the beginning of this period was still partly overflowed by the sea, and in Belgium, Holland, and the South of England, the North Sea extended further over the land than to-day and left behind the deposits known as the Crag. Over the extended mainland of Central Europe, the conditions for the preservation of mammals were, on account of the absence of more extended fresh-water lakes, extremely unfavourable. Only the volcanic tuffs in Auvergne, the fissures filled with Bohnerz of the Upper Rhone valley, and the scattered fresh-water deposits of the Rhone valley, Roussillon and the neighbourhood of Montpellier, contain remains of the Pliocene land fauna, which are handed down in greater perfection in the swampy, and in part coal-bearing, sediments of the Arno valley and in the partly marine formations of Piedmont and the Romagna.

These consist of the following genera[1]:—

Perissodactyla.
Tapirus.
Rhinoceros.
(*Atelodus.*)
(*Cœlodonta.*)
***Equus.**
†*Hipparion* (rare).

Artiodactyla.
Sus.
***Hippopotamus.**
***Cervus** (*Elaphus*).
*(**Polycladus.**)
*(**Axis.**)
*(**Capreolus.**)
***Alces.**
**Dama.*
***Cervulus.**
†**Palæoryx.**
Gazella.
†*Tragelaphus.*
Antilope.
***Bos.**
***Leptobos.**
Bubalus.

Proboscidia.
†**Mastodon.**
***Elephas.**

Rodentia.
Arctomys.
†**Steneofiber.**
***Castor.**
* *Trogontherium.*
Cricetus.
*†*Trilophiomys.*
***Arvicola.**
***Mus.**
Hystrix.
*†*Ruscinomys.*
*†*Pellegrinia.*
**Lepus.*
**Myolagus.*
**Lagomys.*

Insectivora.
Sorex.

Carnivora.
(Fissipedia.)
**Canis.*
†*Hyænarctos.*
***Ursus.**
*†*Ælurus.*
Putorius.
Lutra.
Viverra.
Hyæna.
Machairodus.
Felis.

Primates.
***Semnopithecus.**
*†*Dolichopithecus.*
†*Macacus.*

The above table shows that the ancient genera *Mastodon* and *Tapirus* become extinct in Europe, whilst in North America and in the East Indies they continue into the Pleistocene. Amongst the new genera which spring up, some (*Equus, Hippopotamus, Bos, Lep-*

[1] The genera marked with * appear for the first time in the Pliocene; those marked with † become extinct.

tobos, *Bubalus*, *Elephas*, *Ursus*, *Canis*) appear to have wandered from out of Asia, and these, together with the numerous forms of Deer, which were already split up into several sub-genera, chiefly contribute the peculiar character of the Pliocene fauna. In spite of their modern habitus, the Pliocene forms are linked unconditionally to the older forerunners of the Miocene period, and of not a single order can it be asserted that the thread of continuity between Miocene and Pliocene has been completely broken. But in a far higher measure than previously the dawn of the present time is reflected in the forms of the Pliocene Mammalia. With the exception of some mostly imperfectly known representatives of the microfauna, the only Pliocene genera which are wanting in the present period are *Hipparion*, *Mastodon*, *Hyænarctos*, *Machairodus*, *Leptobos*, and *Dolichopithecus*. A much greater number of genera have indeed forsaken their European dwelling-places and withdrawn into warmer regions. Tropical Africa and India are the places of refuge in which a considerable portion of the Pliocene genera were preserved, and in the course of time more or less transformed. No single Pliocene species has maintained itself unchanged to the present. That the Pliocene fauna of India agreed in character with that of Europe is evident from the fact that the Upper Sivalik beds and the newer deposits in the valleys of the Kistna, Narbada, Jumna, Godavari, and Pemganga, contain not only the same genera, but partly even identical, or nearly identical, species.

The Cetacea, Pinnipedia and Sirenia, which are present in great abundance in the Crag deposits of Antwerp, Holland, and Suffolk, and in the Marine sub-Apennine beds of Italy, occupy a similar intermediate position between the Miocene and the Present to that of the land fauna. They contain the following genera :—

CETACEA.	*Hyperöodon.*	SIRENIA.
Squalodon.	**Choneziphius.**	**Felsinotherium.**
Eurhinodelphis.	*Placoziphius.*	*Halitherium.*
Priscodelphinus.	**Dioplodon.**	
Delphinus.	*Berardiopsis.*	PINNIPEDIA.
Steno.	**Plesiocetus.**	*Pristiphoca.*
Tursiops.	*Heterocetus.*	*Palæophoca.*
Orca.	*Amphicetus.*	*Mesotaria.*
Globicephalus.	*Herpetocetus.*	*Callophoca.*
Physeter.	*Idiocetus.*	*Platyphoca.*
Physeterula.	*Mesocetus.*	*Phocanella.*
Homocetus.	*Isocetus.*	*Gryphoca.*
Physodon.	**Balænoptera.**	*Trichechus.*
Scaldicetus.	*Megaptera.*	*Alachtherium.*
Hoplocetus.	**Balæna.**	
? *Priscophyseter.*	*Palæocetus.*	
? *Physotherium.*		

In North America the so-called Loup Fork or *Pliohippus* beds of Niobrara, Nebraska, Wyoming, Colorado, Kansas, New Mexico, Texas, and Mexico, are usually reckoned to the Pliocene, and they are especially characterized by the abundance of *Mastodon*, *Aphelops*, *Hipparion*, *Pliohippus*, *Protohippus*, *Merychyus*, *Merycochœrus*, Camels, Rodents, and Carnivora. The absence of *Elephas*, horned Ruminants,

Tragulidæ, Deer, Bears, and Apes, gives to this fauna rather a Miocene than a Pliocene stamp, and justifies the opinion of Cope, who places these beds in the Upper Miocene. They contain the following genera:—

PERISSODACTYLA.
Hipparion (E.)
Merychippus.
Protohippus.
Pliohippus.
Equus (E.)
Tapiravus.
Aphelops.

ARTIODACTYLA.
Merychyus.
Merycochœrus.
Protolabis.
Procamelus.
Camelus.
Pliauchenia.
Cosoryx.

PROBOSCIDIA.
Mastodon (E.)

RODENTIA.
Eucastor.
Mylagaulus.
Hesperomys.
Palæolagus.
Punolax.
? *Geomys.*
? *Thomomys.*

CARNIVORA.
(Fissipedia.)
Ælurodon.
Canis (E.)
Leptarctos.
Stenogale.
Mustela (E.)
Brachypsalis.
Lutra (E.)
Pseudælurus.

The Loup Fork beds share with Europe the genera *Equus*, *Hipparion*, *Mastodon*, *Canis*, *Mustela*, and *Lutra*, and with South Asia, *Camelus*. On the whole, this fauna is somewhat further removed from that of the Old World; the specialization of peculiar North American forms, already indicated in the Lower and Middle Miocene, has made visible progress. The bond between the two provinces of the Northern hemisphere has become looser.

In South America the Araucanian Formation of Ameghino may correspond with the Older European Pliocene. At Monte Hermoso, near Bahia Blanca, it has yielded about sixty species of Mammalia, which are divided amongst the following genera:—

MARSUPIALIA.
Didelphis.

EDENTATA.
Gravigrada.
Lestodon.
***Megatherium.**
***Scelidotherium.**
Pseudolestodon.
Diodomus.

GLYPTODONTIA.
**Glyptodon.*
Hoplophorus.
***Plohophorus.**
**Panochthus.*
Neuryurus.
Plaxhaplus.

DASYPODA.
Chlamydotherium.
Dasypus.
**Dasypotherium.*
Procuphractus.
Eutatus.

PERISSODACTYLA.
**Tapirus* (N.)
(*Antaodon.*)
**Hippidium* (N.)
Macrauchenia.
***Epitherium.**

ARTIODACTYLA.
***Auchenia** (N.)
**Eoauchenia* (N.)
**Paraceros* (N.)

PROBOSCIDIA.
***Mastodon** (N.)

TOXODONTIA.
Toxodon.
**Trachythærus.*
**Trigodon.*
Xotodon.

TYPOTHERIA.
Protypotherium.
**Typotherium.*
**Pachyrucos.*

RODENTIA.
**Myopotamus.*
**Tribodon.*
***Eumysops.**
***Dicælophorus.**
**Phthoramys.*
**Platæmys.*
***Pithanotomys.**
Lagostomus.
Megamys.
***Orthomyctera.**
**Microcavia.*
***Palæocavia.**
**Diocartherium.*
**Phugatherium.*
**Hydrochœrus.*
Caviodon.

CARNIVORA.
**Canis* (N.)

The Autochthonous Marsupials, Edentates, Perissodactyla, Toxodonts, Typotheria, and Rodents contain genera, in part handed over

from older strata, in part new (those marked with *), but these represent, almost without exception, only advanced stages of differentiation of older types. But, in this fauna of the Southern world, one sees now, for the first time, a number of entirely foreign intruders intermingled, which betray a different descent. The genera *Tapirus*, *Hippidium*, *Auchenia*, *Eoauchenia*, *Paraceros*, *Mastodon*, and *Canis* have certainly not sprung from the soil of South America, but have migrated from the North, where they already existed, either as identically the same genera or as nearly related representative forms, in the Loup Fork beds. This invasion of strangers from the North shows that the two halves of the Western continent first grew together in the Pliocene period, and that probably at that time a land-bridge, broader even than the present Isthmus of Panama, joined together North and South America and the West Indies.

But not only did the North American types make use of the newly opened way to widen the area of their distribution, but also the forms indigenous to the South began to migrate to the North, and thus brought about one of the most remarkable instances of the overlapping of different faunas which geology has to record. In North America the so-called *Equus*-beds in the West and South-West of the United States (Oregon, California, Idaho, Arizona, New Mexico, Wyoming, Kansas, and Texas), in Mexico and Central America, and the contemporaneous *Megalonyx*-beds in the East (Kentucky, Pennsylvania, Ohio, Carolina, Virginia, Florida), and in the West Indies (Cuba), represent either the last phase of the Tertiary period, or the beginning of the Pleistocene Diluvial period. A peculiar composite fauna of both Northern and Southern descent peopled at that time North America, and left its remains in the deposits just mentioned.

To the Northern types belong the genera *Equus*, *Hipparion*, *Tapirus*; *Dicotyles*, *Platygonus*; *Auchenia*, *Eschatius*, *Holomeniscus*, *Cariacus*, *Cervus*, *Alces*, *Bos*; *Mastodon*, *Elephas*; *Castor*, *Erethizon*, *Castoroides*, *Sciurus*, *Arctomys*, *Jaculus*, *Arvicola*, *Thomomys*, *Geomys*, *Neotoma*, *Lagomys*, *Lepus*, *Scalops*; *Procyon*, *Arctodus*, *Putorius*, *Mustela*, *Lutra*, *Mephitis*, *Canis*, *Urocyon*, *Pachycyon*, *Chrysocyon*, *Arctotherium*, *Felis*, *Machairodus*; whilst to the South American types belong *Megalonyx*, *Mylodon*, *Glyptodon*, *Chlamydotherium*, *Hydrochœrus*, *Amblyrhiza* and *Toxodon*.

Pampas Formation.

The deposition of the *Equus*- and *Megalonyx*-beds in North America may coincide with the formation of the loamy deposits, resembling the widely-distributed Loess, of the so-called "Pampas Formation" in Argentina and Uruguay. Also the volcanic tuffs of Bolivia, Peru and Chili contain mammalian remains which partly repeat those in the *Equus*-beds of Central America, and partly those in the Pampas mud. In its wealth of forms the fauna of the Pampas formation exceeds that now existing in South America. It contains, according to Ameghino, 235 species and 93 genera. Even if a part of the species indicated in his lists will not stand a more critical review, there will yet remain so large a residue of good genera and

species that, on the whole, only the fauna of the Phosphorites and the Bohnerze in Europe, that of the Santa-Cruz formation in Patagonia, and the fauna of the Sivalik Hills can come into comparison with it. Among the specifically South American orders, the Edentates reach, in the numerous kinds of the Gravigrada, Glyptodontia, and Dasypoda, notable dimensions, and in the same way the Toxodonts, Typotheria and the Macrauchenidæ surpass most of their predecessors in size. But this exuberant growth and the extreme specialization of individual organs, which as a rule is associated with it, appear to have been fatal to its possessors, for none of the giant Edentates, Toxodonts, Typotheria, and Macrauchenidæ survived the end of the Pampas formation, and with them, the larger migrants from the North, such as *Mastodon*, *Machairodus*, *Equus*, *Hippidium*, *Mesolama*, *Palæolama*, etc., also became extinct. The invasion from the North, which had already begun during the Araucanian period, introduced a considerable number of new Elements into the South American fauna, among which may be named in the first rank, the Horse, various genera of Carnivora (*Machairodus*, *Felis*, *Mephitis*, *Lutra*, *Nasua*, *Arctotherium*), a very doubtful representative of the Rhinocerotidæ (? *Plicatodon*), a considerable number of small Rodents of the Myomorpha group, and finally —Man himself. The fauna of the Pampas formation contains, according to Ameghino, the following genera[1]:—

MARSUPIALIA.
Didelphys.
†*Dimerodon.*

EDENTATA.
Vermilinguia.
Myrmecophaga.
Gravigrada.
†**Megatherium.**
†*Essonodontotherium.*
†*Neoracanthus.*
†*Ocnopus.*
†*Nothrotherium.*
†*Nothropus.*
†**Mylodon.**
†*Pseudolestodon.*
†**Lestodon.**
†*Laniodon.*
†**Scelidotherium.**
†*Platyonyx.*
†**Glossotherium.**
Glyptodontia.
†**Glyptodon.**
†*Thoracophorus.*
†**Hoplophorus.**
†*Lomaphorus.*
†**Panochthus.**
†*Eleutherocercus.*
†*Neuryurus.*
†**Dædicurus.**

†*Plaxhaplus.*
†? *Heterodon.*
†? *Euryodon.*
†*Plohophorus.*
Dasypoda.
Chlamydophorus.
†*Dasypotherium.*
†**Chlamydotherium.**
Tatusia.
Eutatus.
Tolypeutes.
Xenurus.
Cheloniscus.

PERISSODACTYLA.
†**Equus** (N.)
†**Hippidium** (N.)
†**Macrauchenia.**
†*Diastomicodon.*
Tapirus (N.)
†? *Plicatodon* (N.)

ARTIODACTYLA.
Dicotyles (N.)
Auchenia (N.)
†*Mesolama* (N.)
†*Stilauchenia* (N.)
†*Palæolama* (N.)
†*Hemiauchenia* (N.)
†*Protauchenia* (N.)

†*Eulamops* (N.)
Cervus (N.)
(*Furcifer*) (N.)
(*Cariacus*) (N.)
(*Blastoceras*) (N.)
(*Epieuryceras*) (N.)
Antifer (N.)
Coassus (N.)

PROBOSCIDIA.
†*Mastodon* (N.)

TOXODONTIA.
†**Toxodon.**
†*Dilobodon.*
†? *Eutrigonodon.*

TYPOTHERIA.
†**Typotherium.**
†**Pachyrucos.**

RODENTIA.
Hesperomys (N.)
Habrothrix (N.)
Oxymicterus (N.)
Scapteromys (N.)
Rhipidomys (N.)
Nectomys (N.)
Calomys (N.)
Reithrodon (N.)

[1] The genera marked with † are extinct, those to which (N.) is affixed are of North American origin.

Bothriomys (N.)
Tretomys (N.)
Ptyssophorus (N.)
Holochilus (N.)
Myopotamus.
Ctenomys.
†*Dicælophorus.*
†*Platæomys.*
†*Pithanotomys.*
Schizodon.
Loncheres.
Nelomys.
Mesomys.
Carterodon.
Dolichotis.
Cavia.
Microcavia.
Cerodon.
Hydrochœrus.
Lagostomus.
Lepus (N.)

CARNIVORA.
(Fissipedia.)
Canis (N.)
†*Macrocyon* (N.)
Arctotherium (N.)
Nasua (N.)
†*Amphinasua* (N.)
Lutra.
Mephitis (N.)
Lyncodon (N.)
Felis (N.)
†**Machairodus** (N.)

PRIMATES.
Homo (N.)

If we compare the fauna of the Pampas formation with that now existing in South America, the large proportion of extinct species at once strikes the eye. In this respect it is further removed from that now living in South America than the Pliocene fauna of Europe from its present descendants. On the other hand one finds, however, amongst the fossil animals of the Pampas a large number of still living species, which are altogether missing in the Pliocene of Europe. If we consider, with Ameghino, the Pampas formation as the equivalent of the European Pliocene, we observe that its fauna possesses on the one side a more ancient, and on the other a more modern, character than that in Europe; if, with Burmeister, Steinmann and others, we place it in the Pleistocene, it is distinguished in a remarkable manner from the Diluvial faunas of other parts of the world by the great number of extinct genera and species which are present in it.

It would appear as if the Southern hemisphere required to be measured by a different standard than other places, for Australia also possesses in Bone-caves and in evidently late surface-deposits, generally attributed to the Pleistocene, an extinct fauna, which holds just the same relative position to that now living in that country as the Pampas fauna to that of modern South America. With the exception of a species of Dog (*Canis dingo*) the Pleistocene mammals of Australia belong to the Monotremata and Marsupials, and they are divided amongst the following genera:—

†*Proechidna.*
Perameles.
Dasyurus.
Sarcophilus.
Thylacinus.
Bettongia.
Æpyprymnus.
†*Thylacoleo.*
Pseudochirus.
†*Koalemus.*
†*Archizonurus.*
†*Thylacopardus.*
Macropus.
†*Sthenurus.*
†*Procoptodon.*
†*Palorchestes.*
†*Triclis.*
†*Synaptodus.*
†*Diprotodon.*
†*Nototherium.*
Phascolomys.
†*Phascolonus.*

Here also the fossil extinct genera and species are distinguished by their remarkable size, and just as the Gravigradidæ and the Glyptodontidæ of the Pampas-beds stand out as giants in comparison with the existing Sloths and Armadillos, so also the powerful *Diprotodon, Nototherium, Phascolonus, Sthenurus, Procoptodon, Thylacoleo* and others present a similar contrast to their still existing Australian relatives.

If there prevails in North and South America and in Australia

some uncertainty as to the boundary of the Pliocene and Pleistocene, the case is hardly different in Europe; for here also there is thrust in between the typical Pliocene fauna of the Arno-valley, of Auvergne, and of the neighbourhood of Montpellier, a peculiar pre-Glacial composite fauna, of which the most perfect remains lie buried in the so-called Forest-beds of Cromer, in Norfolk, in the sand and gravel deposits of Saint Prest (Eure-et-Loire), Chagny (Saône-et-Loire), Durfort (Gard), in the clays of Leffe (Lombardy), at the Janiculus near Rome, and in other places in Italy.

As characteristic species of this horizon may be considered the following:—

Equus ? *Stenonis.*
,, *caballus.*
Rhinoceros etruscus.
,, *Mercki.*
(*Rhinoceros leptorhinus.*)
Hippopotamus major.
Sus scrofa.
Cervus Sedgwicki.
,, *verticornis.*
,, *polignacus.*
,, *eurycerus.*
Cervus elaphus.
,, *capreolus.*
Antilope, sp.
Gazella anglica.
Bison, sp.
Bos primigenius.
Elephas meridionalis.
,, *antiquus.*
,, ? *primigenius.*
Castor fiber.
Trogontherium Cuvieri.
Sorex vulgaris.
,, *moschatus.*
Talpa Europæa.
Canis lupus.
,, *vulpes.*
Ursus arvernensis.
,, *spelæus.*
Hyæna, sp.
Machairodus latidens.

Of genuine Pliocene species this fauna contains only *Elephas meridionalis*, *Rhinoceros etruscus*, and *Ursus arvernensis*; only *Cervus Sedgwicki* and *C. verticornis* belong to it exclusively; all the remaining species also occur in the genuine Older Diluvium (Pleistocene).

Pleistocene or Diluvium.

The genuine Pleistocene fauna of the European Diluvium contains about 110 species, whilst the mammalian fauna now living in Europe, including the introduced and domesticated forms, consists of about 150 species.[1]

Perissodactyla.
Equus caballus.
,, *hemionus.*
,, *asinus.*
†*Rhinoceros* (*Cœlodonta*) *antiquitatis.*
†(=*R. tichorhinus.*)
†*Rhinoceros Mercki.*
†*Elasmotherium Sibiricum.*

Artiodactyla.
Sus scrofa ferus.
†*Hippopotamus major.*
† ,, **Pentlandi.**
Cervus elaphus.
,, *Canadensis.*
† ,, *eurycerus.*
† ,, *Belgrandi.*
,, *capreolus.*
,, *dama.*
Alces palmatus.
Rangifer tarandus.
Capra ibex.
,, **pyrenaica.**
,, *hircus.*
Antilope rupicapra.
,, *Saiga.*
† ,, **? Maileti.**
Ovis aries.
† ,, **tragelaphus.**
Ovibos moschatus
†*Bos primigenius.*
,, *taurus.*
†*Bison priscus.*

Proboscidia.
†*Elephas antiquus.*
† ,, **Melitensis.**
† ,, **mnaidriensis.**
† ,, **Falconeri.**
† ,, *primigenius.*

Rodentia.
Arctomys marmotta.
,, *Bobac.*
Spermophilus guttatus.
,, *rufescens.*
,, *fulvus.*
,, *citillus.*
Sciurus vulgaris.
Myoxus glis.
,, *nitela.*
Muscardinus avellanarius.
Alactaga jaculus.
†*Trogontherium Cuvieri.*
Castor fiber.
Hystrix cristata.
Sminthus vagus.
Mus sylvaticus.
,, ? *musculus.*
Cricetus vulgaris.
Arvicola amphibius.
,, *glareolus.*

[1] In the following table only the species from the Mediterranean region are printed in thick type; those with † are extinct.

Arvicola nivalis.
,, *ratticeps.*
,, *gregalis.*
,, *arvalis.*
,, *agrestis.*
Myodes lemmus.
,, *torquatus.*
Lepus timidus.
,, *variabilis.*
,, *cuniculus.*
Lagomys pusillus.
Myolagus Sardus.

INSECTIVORA.
Talpa Europæa.
Myogale moschata.
,, *pyrenaica*
Sorex vulgaris.
,, *pygmæus.*
Crocidura araneus.
Crossopus fodiens.
Erinaceus Europæus.

CHIROPTERA
Vespertilio murinus.
,, *mystacinus.*
Vesperugo noctula.
,, *pipistrellus.*
,, *serotinus.*
,, *borealis.*
Plecotus auritus.
Rhinolophus ferrum-equinum.

CARNIVORA.
Canis lupus.
(= *C. spelæus.*)
Canis lupus Suessii.
Cuon Europæus.
† ,, *Edwardsianus.*
†**Lycorus Nemesianus.**
Canis vulpes.
,, *lagopus.*
† ,, *Mikii.*
†*Ursus spelæus.*
† ,, *priscus.*
,, *arctos.*
Meles taxus.
Gulo luscus.
Mustela martes.
,, *foina.*
Putorius fœtidus.
,, *vulgaris.*
,, *ermineus.*
Lutra vulgaris.
Hyæna spelæa.
(= *H. crocuta* var.)
Hyæna **striata.**
†*Machairodus latidens.*
†*Felis spelæa.*
,, *? tigris.*
,, *pardus.*
,, **caffra.**
,, *lynx.*
,, *catus.*

PRIMATES.
†*Macacus Suevicus.*
,, **Inuus.**
Homo sapiens.

With the exception of *Elephas primigenius*, *Rhinoceros antiquitatis*, *R. Mercki* and *Cervus eurycerus*, the extinct species belong to the Older pre-Glacial or inter-Glacial Diluvium. *Hippopotamus major* is only a larger variety of the African *Hippopotamus*, and similarly *Felis spelæa* and *Hyæna spelæa* stand in the same relation to the Lion and to the African spotted Hyæna. To the pre-Glacial, or, perhaps better, to the inter-Glacial deposits, are reckoned the older stratified gravels, sands and clays of the Seine- and Somme-valleys in Northern France, of the Thames- and Ouse-valleys in England; of the Rhine and Neckar districts (Daxlanden, Mannheim, Worms, Mosbach near Wiesbaden, Mauer near Sinsheim, Hangenbieten in Alsace); the calc-tuffs and sands of Cannstadt and Taubach near Weimar; the inter-Glacial brown coals, gravels and sands of Utznach and Dürnten; the older stratified gravel and sand deposits in the Rhone valley, in Switzerland, in the Swabish-Bavarian high plateau; in the Vienna basin, in Hungary, Roumania, South and Central Russia; in the North German plain (Rixdorf), Italy, and Spain.

As characteristic elements of the Older Diluvial fauna may be placed in the first line *Elephas antiquus*, *E. primigenius*, *Rhinoceros Mercki*, *Equus caballus*, *Trogontherium Cuvieri*, *Castor fiber*, *Sus scrofa*, *Cervus eurycerus*, *C. elaphus*, *C. capreolus*, *Bos primigenius*, *Bison priscus*, *Ursus spelæus*, *Hyæna spelæa*, *Machairodus latidens*, *Canis lupus* and *vulpes*, which already appear in the Forest-beds near Saint Prest, Durfort, etc., as also *Felis spelæa*, *F. lynx*, some small Rodents and Insectivora. The Pliocene forms, *Elephas meridionalis*, *Rhinoceros Etruscus*, and *Ursus Arvernensis*, are extinct or, rather, replaced by closely related successors. The entire pre-Glacial and inter-Glacial fauna of Europe required a rich vegetation and a mild climate, which probably corresponded to that of the Mediterranean region of to-day; in no case was it more severe than that of Central

Europe at present. Northern or mountainous forms are still wholly absent; on the other hand the presence of Man is affirmed by the abundant occurrence of rudely worked flint implements of the "Chelléen-type." Whilst this Older Diluvial fauna peopled Europe and Northern Asia, the Ice-Age commenced and evidently destroyed a number of forms which could not adapt themselves to the changed climatic conditions, as *Hippopotamus*, *Elephas antiquus*, together with its dwarf races (*Elephas Melitensis*, *mnaidriensis* and *Falconeri*), *Elasmotherium*, *Trogontherium* and *Machairodus*. An invasion of cold-loving land animals, which to-day find their homes partly in the high North, partly in the rugged Asiatic Steppes, or on high mountainous regions, took place, and they became mingled with the surviving elements of the Older Diluvial fauna. The Mammoth (*Elephas primigenius*) and woolly Rhinoceros (*Rhinoceros antiquitatis*) now reach their maximum distribution, and through the great development of their hairy coats they were perfectly matched to the harsher climate; *Rhinoceros Mercki* also survived, and left behind, as did also both the other species, well preserved bodies in the frozen soil of Siberia. Besides these, the Reindeer (*Rangifer tarandus*) and the Horse belong to the most abundant forms of the Glacial fauna, and with them are found, although less frequently, the extreme northern Musk-sheep (*Ovibos moschatus*) besides boreal forms like the Lemming (*Myodes lemmus*), the collared Lemming (*M. torquatus*), the Voles (*Arvicola nivalis* and *ratticeps*), the Glutton (*Gulo luscus*), the Ermine Stoat (*Putorius ermineus*), the Arctic Fox (*Canis lagopus*), and such Asiatic Steppe-dwellers as the Wild-Ass (*Equus hemionus*), the Saiga Antelope, the Bobak, the pouched Marmots (*Spermophilus*), the Jerboa (*Alactaga*), the tailless Hare (*Lagomys pusillus*), the Shrew (*Myogale moschata*) and forms which live on high mountains, as the Chamois, Ibex, the Alpine Marmot, and the Alpine Hare (*Lepus variabilis*). The majority of the endemic land-mammals which still live in Northern and Central Europe, also formed part of the Glacial and post-Glacial fauna, and all these animals are found, as a rule, mixed up together and washed into rock-fissures and caves which served as dwelling-places for such Carnivora as the Cave-bear, the Cave-hyæna and the Wolf. The Löess also contains the Middle Diluvial Glacial fauna still in great perfection and it is particularly distinguished by the presence of the Mammoth, *Rhinoceros tichorhinus*, Reindeer, Musk-sheep, Deer, Bison and Urus.

After the melting of the gigantic Diluvial Glaciers, certain northern forms, such as Reindeer, Lemming, collared Lemming, Glutton, *Spermophilus*, *Lagomys* and Jerboa, still maintained themselves for a time in Central Europe, and they characterize the Younger Section (Nehring's[1] period of the Steppe-fauna) of the Palæolithic stage of civilization. The human reliquiæ in the caves of Perigord, of Belgium, of Thayingen and of Schweizerbild near Schaffhausen, and the settlement in the turf of Schussenried in Upper Swabia, furnish excellent instances of the composition of the fauna

[1] Nehring A. Ueber Tundren und Steppen der Jetzt-und Vorzeit. Berlin, 1890.

during the so-called Reindeer period.[1] With the commencement of our present climatic conditions, the Forest-fauna of to-day (Squirrel or Aurochs-period) then spread itself over Central Europe, and with this began the taming and importation of domestic animals by man, and consequently a fundamental change in the composition of the animal surroundings of the men belonging to the Newer Stone period.[2]

The Diluvial fauna sketched above peopled not only Europe, but also Northern and Central Asia. According to Brandt[3] some characteristic forms are entirely wanting in Asia, as Hippopotamus, Ibex, Chamois, Fallow-deer, Cave-bear and Wild-cat; as against these the Asiatic Diluvial fauna contains *Antilope gutturosa*, *Capra Sibirica* and *ægagrus*, *Ovis Argali*, *Moschus moschiferus*, *Siphneus Aspalax*, *Ellobius talpinus*, *Spalax typhlus*, *Sminthus vagus*, *Tamias Pallasi*, *Mustela zibellina*, *Felis tigris*, and *Canis Nishneudensis*. Brandt[4] maintains that Northern Asia, and especially the high northern latitudes, form the region where the European, North Asiatic and North American land-faunas had been concentrated during the Tertiary and Diluvial periods, and from whence issued the migrations and forward movements to the South and West, according to the degree in which the colder climate advanced. As the Northern fauna spread itself over more Southern latitudes during the Diluvial period, it occupied the dwelling-places of the forms which had there survived from Tertiary times, it crowded them into sub-tropical and tropical regions, and itself formed the proper stock of the Diluvial fauna.

Although, according to the concordant testimony of Russian geologists,[5] Siberia, in contrast to Europe and North America, was not completely covered by a continuous Ice-sheet during the Glacial period, and only possessed glaciers of limited extension, it nevertheless experienced a deterioration of its climatic conditions and a considerable decrease of temperature, so that only the more readily adaptable constituents of the pre-Glacial fauna were able to maintain their position. Others succumbed to the less favourable conditions of existence, or were obliged to emigrate. The gradual penetration of the frost into the ground and the damming up of the rivers by ice also produced in Siberia, at that time, the conditions for the preservation of entire carcasses of the Mammoth, Rhinoceros, Bison and Musk-sheep.

The Glacial and post-Glacial fauna of North America is much

[1] Nehring A. Uebersicht über vierundzwanzig mitteleuropäische Quartär-Faunen. Zeitsch. d. deutsch. geol. Ges. 1880, p. 468.

[2] Woldrich, J. N., Die diluvialen Faunen Mittel-Europa's. Mitth. Anthrop. Ges. Wien. 1882, xi.

[3] Brandt, J. Fr. und Woldrich, J. N. Diluviale europäisch-nordasiatische Säugethierfauna und ihre Beziehungen zum Menschen. Mém. Acad. imp. St. Pétersbourg, 1887, vii. sér. xxxv. No. 10.

[4] Naturgeschichte des Elens. Mém. Acad. imp. St Pétersbourg, xvi. pp. 39–50.

[5] Tschersky, J. D. Wissenschaft. Ergebnisse d. Neusibirischen Expedition d. J. 1885 und 1886, iv., Posttertiäre Säugethiere. Mém. Acad. imp. St. Pétersbourg, 1892, xli. p. 455, 511.

poorer in species than that of Europe; it has, moreover, been less studied, and at times it is difficult to separate it from that of the older *Equus*-beds. As characteristic species may be mentioned, *Mastodon Americanus, Cervus alces, Cervalces Americanus, Rangifer tarandus, ? Cervus Canadensis, Bos Americanus, Ovibos bombifrons, Canis lupus, Ursus ferox, ? Felis atrox.* Noteworthy is the absence of *Equus, Rhinoceros, Hippopotamus, Dicotyles, Sus, Machairodus, Ursus spelæus, Felis spelæa, Hyæna spelæa, Bison priscus, Bos primigenius, Cervus elaphus, capreolus, eurycerus,* and a great number of other forms abundant in Europe and Northern Asia. The Diluvial Mammalian fauna of North America stands in precisely the same relation to that of Europe as the existing faunas of the two continents bear to each other. Identical species are extremely rare; on the other hand the general character is similar, and points to a common origin.

In South Asia and South America the Diluvial faunas succeeding those of the Tertiary period consist for the main part of species still existing, but they show somewhat closer ties to their Tertiary forerunners.

From the whole history of Mammalian development, from the Trias to the present time, it becomes definitely evident, in spite of all the deficiencies in the Palæontological record, that the genetical connection between particular faunas, notwithstanding manifold interruptions from geological events, was never completely broken, and that each particular assemblage of animals has been produced by the gradual transformation of its elements from an earlier preceding one, and at the same time it has yielded the seed for that next succeeding. Certain genera (*Didelphys, Sciurus, Myoxus, Sorex*) belonging to the micro-fauna can be traced back into the Eocene, and they have indeed produced new species since their first appearance, but have experienced no transformation worth mentioning, as also the Polyprotodont Marsupials, Insectivora and Rodents, which represent generally the least changeable types of Mammalia. Recent genera of more considerable size make their appearance in constantly increasing numbers from the Lower Miocene onwards, and they partly continue up to the present day.

Our entire animal and plant environment is incontestably rooted in former periods, and in no class of animals does the intimate connection between the past and the present stand out sharper to the view than in the Mammalia.

Concerning their origin and earliest distribution in Mesozoic time there is still wanting, unfortunately, satisfactory information, but the uniformity of the Jurassic Mammalian faunas in Europe and North America, which consist of Allotheria and Polyprotodont Marsupials (or primitive, perhaps marsupial, Insectivora); the appearance of a typical Allotherian genus in the South African Trias; and the great resemblance of the Upper Cretaceous genera to their Jurassic forerunners, make it extremely probable that in the Mesozoic period a single uniform Mammalian fauna peopled Europe

(and possibly also Asia), North America and Africa. Whether to this extensive zoo-geographical kingdom Australia also belonged at the same time, or whether, as has often been stated, the Mesozoic forms withdrew themselves there at a later period, cannot, for lack of the needful proofs, be determined with certainty. Under any circumstances the present Australian mammals must in this case have been very radically changed, and they now retain only a few features of their very ancient ancestors.

From the Tertiary period onwards, the distribution of the land mammalia went forth from certainly not more than three areas of development, or so-called 'centres of creation.'

I. The oldest, the earliest separated off from the rest, and still the mostly distinctly bounded of all the zoo-geographical kingdoms, is formed by Australia, with the neighbouring island of Tasmania. In spite of great diversity with regard to climate and meteorology, and in spite of striking differences in the conditions of food support, this kingdom contains the whole of the now existing Monotremata and Marsupials with the exception of the Didelphyidæ, which live to-day in America and in the Tertiary period were also distributed over the whole northern hemisphere; and beyond these only a few forms, probably imported from outside at a later period, such as Bats, Mice (*Pseudomys, Hydromys, Acanthomys. Hapalotis, Echiothrix*), and the Dingo, a variety of the domestic dog. According to A. R. Wallace,[1] Australia was already separated from the other continents at the close of the Mesozoic period; moreover, during a portion of Tertiary time it still included New Guinea, Celebes, the Solomon and perhaps also the Fiji islands, and possessed a considerable extension towards the South and West. Even to-day, Australian Marsupials are met with in New Guinea, Celebes, Amboyna, and even in Timor, mingled with Indian placental Mammals. For its connection at one time with South America, the abundant occurrence of fossil Marsupials in the Santa-Cruz beds of Patagonia is valid evidence.

II. The second zoo-geographical kingdom, formerly not less sharply defined than the Australian, is South America or Austro-Columbia.[2] Up to the youngest Tertiary period this kingdom contained only Edentates, Toxodontia, Typotheria, some very peculiarly differentiated Perissodactyla, Hystricomorphous Rodents, Platyrhine Apes, and Marsupials, which, however, very considerably differ from the Australian forms of this group. From this area of development, Africa received, probably at the beginning of the Tertiary period, some scattered wanderers, such as the forerunners of *Orycteropus* and *Manis*, the Hyracoidea, which have perhaps descended from a common root with the Typotheria, and some Hystricomorphous Rodents. But the connection of the South American or Neo-Tropical kingdom with Australia and South Africa, which at one time existed, must certainly have been already again dissolved in the older Tertiary period, for the forms belonging to

[1] Wallace, A. R., The Geographical Distribution of Animals, 1876.
[2] Huxley Th. Proc. Zool. Soc. London, 1868, p. 316.

the same orders in the three continents have had sufficient time to become specialized in an altogether peculiar manner. How at the close of the Tertiary period the Southern and the Northern half of America grew together, and how the faunas of both divisions were mutually pushed over and through each other, has already (pp. 504–505) been sufficiently described.

III. The third and largest zoo-geographical kingdom, the Arctogæan, includes not only Europe, Asia, and Africa, but also North America. Although all Palæontological traditions respecting the older Tertiary period in Asia and Africa are up to now still wanting, nevertheless, neither the prolific Mio-Pliocene mammalian fauna of Asia, nor the scanty remains from the younger Tertiary formations of Africa, nor the composition of the still existing fauna of South Asia and Africa, can give rise to even a suspicion that along with the known Mammalian races in the older Tertiary of Europe and North America, there could have originated yet another heterogenous fauna in any part whatever of Eurasia. The Tertiary forms of Europe and North America, known up to the present, completely suffice to show that the Mammals of Europe, Asia, Africa, and North America are derived from them (with the exception of some forms conjectured to have wandered from Australia and South America). The Palæarctic, Nearctic, Ethiopic and Indian kingdoms of Sclater and A. R. Wallace form for the Mammals (as Huxley has already pointed out) a single distribution region, which indeed, during the Tertiary and Diluvial periods became already split up into several provinces. The connection with North America was the earliest to be loosened, and already in the Miocene and Pliocene, the New World stood, as against the Old, as an independent zoo-geographical province; which, indeed, after the Ice-age, again received some northern guests, probably from Eastern Asia. To Southern Asia and Africa a portion of the heat-loving animals, especialy Ungulates, Carnivora and Apes, withdrew themselves at the close of the Tertiary period and peopled a province which reached from the West Coast of Africa as far as the Chinese Sea, and may still further have embraced the coast districts of the Mediterranean Sea. In the newer Tertiary period, Ceylon, the Sunda Islands, the Philippines, and Madagascar certainly stood in connection with the neighbouring continents, and received from these their supply of land Mammals. Africa and South Asia even now possess a number of genera in common, and they contain, strictly taken, a single mammalian fauna which probably as late as the Diluvial period became so far differentiated that it can to-day be divided into two independent provinces. Madagascar, with the Mascarene Islands, maintains the same rank as the Indian and Ethiopian provinces. The land Mammals of this small region display unmistakable features of a great isolation at an early period. Excepting the Swine, and some small, as a rule, passively wandering Rodents, most of the Mammals belong to peculiar, specifically Madagascar genera. The numerous Lemurs call to mind their Upper Eocene forerunners in Europe, and even the Carnivora (Cryptoproctidæ)

and Insectivora (Centetidæ) point to ancestors in the older Tertiary. Indigenous Ungulates are wholly absent in this Island region.

In contrast to this ancient (Madagascar) province, Europe and Northern Asia (the so-called Palæarctic region) possess the youngest Mammalian fauna. This first became modified in the Diluvial period, probably under the influence of the Ice-age, and it gradually received a character different from that of the Ethiopic-Indian fauna. Whether also Man, the most youthful figure in the animal world, has originated within this youngest fauna, or whether his cradle, as Ameghino believes, must be sought for in another portion of the world, cannot be provisionally determined with certainty.

VI.—Note on *Myalina crassa* (Fleming).

By Wheelton Hind, M.D., F.R.C.S., F.G.S.

THE genus *Myalina* was erected by Prof. De Koninck, in his Description des Animaux fossiles qui se trouvent dans le terrain Carbonifère de Belgique, for certain Modioliform shells, and M'Coy re-defined the genus in his British Palæozoic fossils and described two forms from the Permian of Durham.

King, "Permian Fossils," describes the same two shells under *Mytilus*, but in the text discusses the propriety of placing them in De Koninck's genus *Myalina*. The characteristic points of this genus to which I wish to draw attention are the presence of triangular septa in the beaks (Myophores), which are shown in casts as deep slits beneath the beaks, umbones terminal, a flattened bevelled striated hinge-plate; all of which characters are shown in King's figures, Palæontograph. Soc. vol. iii. 1849, Mon. "Permian Fossils," pl. xiv. figs. 1 to 13.

So much, then, for the characters of *Myalina*. Now, in the Ann. and Mag. Nat. Hist. series iv. vol. xv. 1875, is a paper on *Myalina crassa* by Mr. R. Etheridge, jun., where he describes a shell, obtained from various localities in the Lower Carboniferous of Scotland, under this name, and gives five beautiful figures, four of which show the hinge-plate or interior.

On reference to these it will be noted at once that in this shell the umbones were not terminal, and they possessed no rostral plates, and in his complete and perfect description he says: "Beaks not quite terminal." "Anterior end forms a small lobe in front of the beaks and umbonal ridges." "Anterior adductor impression double pit-like and deep-placed within the umbonal cavity." It is nearly always treble.

I have had this year the opportunity of examining more than a hundred specimens in museums and at the locality given for the shell by Mr. Etheridge, Cults Lime Works, Pitlessie, and while agreeing in every important detail with his masterly description I cannot understand why he placed the shell in the genus *Myalina*, as it differs so entirely from the typical members of that group in the Permian.

This shell was originally described by Fleming in the Edinburgh

Phil. Journ. 1825 as *Modiolus sp.*, and in 1828 in his British Animals as *Mytilus crassus*, and was referred by King, "Permian Fossils," p. 159, to *Myalina*, in which he was followed by Huxley and Etheridge, Cat. Foss. Mus. Pract. Geol. p. 110, 1865; by Armstrong and Young, Cat. Carb. Foss. W. Scot., 1871; Capt. Brown referred to it as *Avicula*, Foss. Conch., 1849.

Salter, in Geol. Surv. Mem. Iron Ores of S. Wales, p. 228, in mentioning those Mytiliform shells now known as *Anthracoptera*, hazarded the name *Myalina*, which he subsequently altered to *Anthracoptera*, Geol. Surv. Mem. Country around Wigan, 1862, on account of the "absence of the striated hinge-plate of *Myalina*," a character which I have shown (Quart. Journ. Geol. Soc. vol. xlix. 1893, pl. vii. figs. 1, 1*a*, 1*b*, 2, 2*a*) they possess.

And indeed there is no one anatomical point in the shells of the so-called *Myalina crassa* which differs from those of *Anthracoptera*.

Meek and Worthen, in the Geological Survey of Illinois (Palæontology), refer the Mytiliform shells of the Coal-measures to *Myalina*, and Barrois, in his "Recherches sur les terrains anciens des Asturias et de la Galice," p. 334, remarks on the close resemblance between *Anthracoptera* (Salter) and *Myalina*, and thinks it impossible to distinguish between them. He describes *Myalina triangularis* and *carinata* from Spanish beds, and considers that *Myalina* is synonymous with *Anthracoptera*.

The *Myalina crassa* and various forms of *Anthracoptera* belong therefore, I believe, to the same genus, which I think can be separated from the true *Myalinas* of the Permian by the absence of rostral myophores and the umbones not being terminal.

I propose to substitute the name *Anthracoptera crassa* for that of *Myalina crassa*. The fauna of the bed in which it occurs at Cults is interesting, bearing on the salt or brackish origin of these beds. I find it associated there with *Spirorbis carbonarius*, *Stigmaria*, scales of *Megalicthys*, rolled corals, *Zaphrentis*, *Aviculopecten* and Encrinite remains. Mr. Etheridge mentions its occurrence with *Schizodus* and other marine forms at other places in Scotland.

I am able to give another locality for this shell, viz. Beith, Ayrshire, on the authority of Messrs. Young and Armstrong.

REVIEWS.

I.—Transactions of the Seismological Society of Japan, vol. xvi. 1892. pp. 120.

Contents:—(1) C. A. W. Pownall: Notes on recent publications relating to the effect of earthquakes on structures, 1. (2) C. A. W. Pownall: Appendix to the above notes, 14. (3) S. Sekiya and F. Omori: Comparison of earthquake measurements made in a pit and on the surface-ground, 19. (4) J. Milne: A mantel-piece seismometer, 47. (5) W. K. Burton: Notes on seiches observed at Hakone Lake, 49. (6) F. Omori: A note on diagrams from seismographs recording vertical motion, 53. (7) J. Milne: [Epitome of the] Report of the Chirikioku (Meteorological Department) in Tokio on seismometrical observations made in Japan during the year 1888, 55. (8) J. Milne: ditto, during the year 1889, 81. (9) Obituary notice, His Majesty David Kalakaua, 119.

THE SEISMOLOGICAL JOURNAL OF JAPAN. Vol. i. 1893 (corresponding to Transactions of the Seismological Society, vol. xvii.) : edited by Prof. J. Milne, F.R.S. pp. 151

Contents :—(10) J. Milne : On the investigation of earthquake effects and certain experiments in earth physics, 1. (11) W. K. Burton : On the application of photography to seismology and volcanic phenomena, 21. (12) J. Milne : Seismometrical observations for the year 1890, 31. (13) J. Milne and F. Omori : On the overturning and fracturing of brick and other columns by horizontally applied motion, 59. (14) J. Milne : Earth pulsations in relation to certain natural phenomena and physical investigations, 87. (15) J. Milne : On the movements of horizontal pendulums (an abstract, with notes on observations made by Dr. E. von Rebeur-Paschwitz), 113. (16) F. Omori : A note on early Chinese earthquakes, 119. (17) J. Milne : A note on the great earthquake of October 28th, 1891, 127.

The Seismological Society of Japan was founded in 1880 and ceased to exist in 1892, having in the interval issued sixteen volumes of Transactions, which are known and valued wherever earthquakes are studied. Their publication, indeed, formed the principal work of the Society, and, when latterly the attendance at the meetings declined from various causes, scarcely any break of continuity occurred when the Society was dissolved and the Transactions were replaced by the Seismological Journal. It will be seen that in the new work, as in the old, Prof. Milne is the chief contributor, and one can hardly wish that he should be spared the labour of much writing. But that the cost of its production should also fall upon him is greatly to be regretted, and, unless that burden is removed, it would be too much to expect that the publication of the Journal will be very long continued.

Some of the work described in the two volumes above mentioned is already known in this country through Prof. Milne's admirable reports to the British Association. The last paper, for example, is reprinted with the addition of a few lines from the report read at the Edinburgh meeting, and in the same volume will be found summaries of the papers numbered above (7), (8) and (13). A reference to the more important of the remaining papers will, therefore, be sufficient here.

(3) It has frequently been noticed that earthquakes are felt more strongly on the surface than at the bottom of mines, and, for severe earthquakes, the commonly received opinion is supported by some observations made by Prof. Milne in 1884 and 1885. These have been continued by Messrs. Sekiya and Omori, and, in a very interesting paper, they have described their results so far as regards the horizontal component of the motion. The observations were made in a pit, 4 feet square and 18 feet deep, and situated only a few yards from the seismological observatory of Tokio University. The soil is hardened alluvium, and the bottom of the pit is paved with brick to a depth of two feet. On this were placed a pair of Prof. Ewing's horizontal pendulum seismographs in E.—W. and N.—S. directions, so that their records could be compared with those of similar instruments on the surface. Between January 15th, 1887, and April 18th, 1889, the records of thirty earthquakes were collected, three of them being severe shocks, and the remainder slight ones

like those which are felt almost daily in Japan. In the following table are given the average ratio (mean of both components) of the amplitudes (A), periods (B), maximum velocities (C), and maximum accelerations (D), as observed on the free surface ground to those observed in the pit:

	A	B	C	D
Slight earthquakes	1·2	1·0	1·3	1·6
Severe earthquakes, large undulations	1·4	1·1	1·3	1·3
Severe earthquakes, ripples	2·2	0·8	2·8	4·7

These figures show that, for small earthquakes and for the principal undulations of severe earthquakes, there is not very much difference between the surface and underground observations; but that the difference is considerable for the ripples or small quick vibrations which precede and are superposed on the larger waves. In severe earthquakes these ripples are very prominent, and, being very quick in period though small in amplitude, their maximum accelerations, and consequently their overturning and fracturing effects, are very much greater than those of the principal waves. In the pit, these ripples are in part smoothed away, and their average maximum acceleration is only about one-fifth that of the ripples recorded on the surface. It thus appears that in times of severe earthquakes, there should be less destructive action in deep pits than on the surface of the ground.

(10) This paper deals chiefly with the construction of buildings in earthquake countries. Perhaps the most interesting part is that which relates to the possible issue of earthquake warnings. Previous attempts in this direction have failed, but Prof. Milne justly urges further inquiry before we relinquish what may seem an impossible task. The plan he suggests at all events appears worth trying. Starting with the hypothesis that "earthquakes are the result of faulting, and that faulting is due to a bending of the earth's crust beyond its limits of elasticity," he proposes that a very long water-level should be placed at right angles to an axis of elevation, or, better, two such levels at right angles to one another. It might thus be ascertained whether secular changes of level are measurable by such an apparatus, and, if so, whether they are in any way connected with the occurrence of earthquakes.

(14) One of the subjects which have been studied most closely by Prof. Milne is that of earth-pulsations. Several instruments have been used by him, levels, tromometers of various lengths, pendulums, whose movements have been magnified in different ways and also made self-recording, and finally a conical pendulum, of which a description will be found in the British Association Report for 1892 (pp. 107–8). In his earlier work, Prof. Milne discovered that a connection exists between earth-pulsations and local or distant winds. His later researches show that there is a still closer connection with the barometric gradient. With high gradients pulsations have always occurred, and with moderate ones they have generally been present. They are also most frequent during the winter season, when the barometric gradients are steepest. Prof. Milne considers that these pulsations are long flat waves of various amplitudes and

lengths, not altogether unlike the swell upon an ocean. In period they range from one to four or five seconds, their maximum slope being roughly from 1 in 200,000 to 1 in 40,000, *i.e.* from about 1″ to 5″. He believes that they may be due to fluctuations in atmospheric pressure, acting over considerable areas of the earth's crust, not necessarily taking place at the spot where the fluctuations are observed; for, as he shows, the pulsations if produced in this manner might outrace their cause. Towards the end of the paper, Prof. Milne discusses the possible connection of earth-pulsations with the rate of escape of fire-damp in mines. He also shows that the zero of a delicate balance may be temporarily altered by earth-pulsations, and that consequently in weighing by the "method of vibrations" the results may be slightly inaccurate. In the same way, errors may perhaps occur in pendulum experiments and in the delicate work of astronomical observatories.

(16) Mr. F. Omori summarizes the accounts which he has collected from histories and chronicles of 908 shocks, or groups of shocks, felt in China previously to the year 1644. Two districts are especially characterized by earthquakes, one consisting of the three northern provinces of Kansu, Shense, and Shanse, which have often been the seat of extensive and violent earthquakes; the other, the south-western province of Yünnan, where the shocks are mostly local. These Mr. Omori considers to be distinct seismic regions, for they show no coincidence in their epochs of maximum disturbance. The meizoseismal area of several earthquakes, he finds, was an elongated valley tract, and in such cases the disturbed area was generally extended in a perpendicular direction.

C. Davison.

II.—Palæontology of New York, Vol. VIII. Part II. Fascicle I. An Introduction to the study of the genera of the Palæozoic Brachiopoda. By James Hall, assisted by John M. Clarke. Albany, New York, July, 1893. (Charles Van Benthuysen & Sons.)

OWING to unavoidable delay in printing the lithographic plates designed to accompany the second volume of Hall and Clarke's monumental work on the genera of the Palæozoic Brachiopoda, the authors deemed it advisable to issue a part of the edition in the form of fascicles. The first of these was published in July last and treats exclusively of the spire-bearing genera. It contains 176 pages of text, accompanied by numerous woodcuts, and although it lacks the illumination of the plates we welcome its appearance gladly as a further instalment of the excellent work that has already effected a revolution of thought in the world of brachiopodists.

The method and text of the first fascicle of the second volume are as excellent as those of the first. The subject-matter called for less rigorous treatment, as the various spire-bearing forms had been carefully investigated by Dr. Davidson, by the light of the Rev. Norman Glass's excellent preparations of the variously modified spiral calcified supports of the brachial organs. The Carboniferous

species of India had also been well described and illustrated by Waagen, and the post-Palæozoic genera, comparatively few in number, by Bittner and other authorities. So that ample material awaited the New York palæontologists, who have now given us a complete survey of this interesting group of fossil Brachiopoda, with special reference to the American species.

The authors commence with the variable and numerous species of the genus *Spirifer*, of which they concur in recognizing Martin's *Anomites striatus* as the type. About two hundred American Palæozoic species are recorded and subjected to careful comparison and revision. They are held to be all congeneric, and the species are therefore (not for the first time in the history of the genus) classed in groups in accordance with the manifold external variations and salient features of an ornamental character.

This method of comparison leads the authors to formulate the novel and highly suggestive conclusion "that these external differences make an excellent basis for a grouping of the members of this protean genus, and one not merely conventional and arbitrary, since it serves to indicate, within the integrity of the genus, lines of progress leading to resultants which are no longer congeneric" (p. 11).

We summarise the classification they propose of six main groups of species, viz.:

I. Radiati. A primitive type with few, many, or double plications, of which *S. radiatus*, including *S. plicatellus*, Sby., are held to be typical examples.

II. Lamellosi. *a. Septati*, with a median septum in the pedicle valve. *S. permallosus*, Hall, is given as a typical example.
b. Aseptati, without median septum, *S. mucronatus*, Conrad, and *S. sub-mucronatus*, Hall.

III. Fimbriati. *a. Unicispini = Delthyris*, Dalman, *sensu stricto*, with short, simple, hollow spines, such as *S. crispus*, Hisinger.
b. Duplicispinei = Reticularia, M'Coy, with large compound spines, often with lateral branches, of which *S. fimbriatus*, Conrad, is the earliest example from the Hamilton group, *S. lineatus*, Martin, a well-known Carboniferous form.

IV. Aperturati. Forms with plications on the sinus fold and sinus, of which *S. aperturatus*, Schlotheim, *S. disjunctus*, Sby., and *S. striatus*, Martin, are cited as typical examples.

V. Ostiolati. Median fold and sinus without plication, such as *S. ostiolatus*, Schlotheim, *S. Oweni*, Hall. These are the syringothyroid spirifers.

VI. Glabrati. Smooth shelled species sub-divided into:
A. Aseptati = *Martinia*, M'Coy, type *S. glabra*, rare in America.
B. Septati, with dental plates or septa well developed, again subdivided into:
1. *Martinopsis*, Waagen's genus, for species with lamellæ in both valves, from the Productus limestone of India.
2. *Tschernyschew*, type *Martinia semiplana*, Waagen, for shells with a prominent median septum in the pedicle valve and dental lamellæ scarcely developed.

Messrs. Hall and Clarke consider, however, the latter as probably congeneric with Quenstedt's genus *Mentzelia* (*Spirifer mediannus*), from the Silesian Muschelkalk. They hold them to be connected with the post-Palæozoic members of the genus *Spiriferina* from the presence of the median septum, and associated with the glabrate *Spirifer* on account of the punctation of the epidermal layer of the shell: This classification of the American species of *Spirifer* is presented in a convenient tabular form, with time limits of species indicated, and will stand examination better when it can be compared with the plates destined to illustrate the volume.

Dalman's genus ? *Cyrtia* and Davidson's *Cyrtina* are retained. The latter comprises the first indication of shell puncture among the Spiriferoids. Winchell's genus, *Syringothyris*, is considered as defining species "outcome from Spirifer along the line of the Ostiolati," while D'Orbigny's *Spiriferina* covers species with characters derived from the lamellose-septate Spirifers dating from Upper Silurian times. The genus *Ambocœlia*, Hall, is a small spire-bearing Devonian type, and his new genus *Metaplasia* is proposed for a little shell originally described as *Spirifer pyxidatus*, but not yet proved to be a spire-bearer, while its external form recalls that of *Orthis*. It is somewhat allied to *Spirifer cheiroptyx*, D'Arch. and De V., from Paffrath, and to *S. Oceani*, D'Orb., from the Carboniferous limestone of Visé, and for this aberrant group Hall and Clarke suggest the designation *Verneuilia*. The term *Whitfieldella* is proposed for certain forms of Meristoids, of which *Atrypa nitida*, Hall, is taken as the type, hitherto described as *Meristina*, that generic name being now restricted "to species similar to *M. Maria*, Hall, which these authorities do not consider to be specifically identical with *Atrypa tumida*, the tpye of Davidson's non-acceptable genus *Whitfieldia*, a synonym of *Meristina*.

In all, Hall and Clarke now recognise forty-eight genera of Palæozoic spire-bearing Brachiopoda, of which twelve new genera and subgenera are now described and figured by the authors for the first time. Twelve others have been admitted as valid by various authors since Davidson's Summary and Appendix was published in 1884. The claims of a few others, such as King's genus *Cliothyris*, type *Athyris pectinifera*, *Actinoconchus*, M'Coy, (*Athyris planosulcata*) and *Seminula*, M'Coy (*A. ambigua*), are readmitted, and the balance remain much as Davidson defined them, with the exception of his genus *Bifida*, which the American palæontologists regard as synonymous with *Anoplotheca*, Sandberger, and *Anazyga*, Dav., based on *Atrypa recurvirostra*, which is merged in *Zygospira*, type *Producta modesta*, Say. The divergent *position* of the loop is shown to be a matter of individual variation, of which *Zygospira modesta* and *Z. recurvirostra* (*Anazyga*) represent "extreme possibilities of variation." Winchell and Schuchert's supposed primitive terebratuloid genus *Hallina* is also referred to *Zygospira*, which seems to be represented by numerous species in the Trenton, Hudson River group and Niagara shales of America.

We subjoin a list of the new genera proposed by Hall and Clarke with the types on which they are founded.

METAPLASIA, type *Spirifer pyxidata*, Hall. WHITFIELDELLA *Atrypa nitida*, Hall. HYATELLA, type *Athyris junia*, Billings. CAMAROSPIRA, type *Camarophoria eucharis*, Hall, for shells essentially meristoid, but differentiated by "greater convergence of dental plates which restrict the impression of the pedicle muscle to a distinct chamber or spondylium."

PTYCHOSPIRA, type *Terebratulata ferita*, Von Buch.

HUSTEDIA, type *Terebratula Mormoni*, Marcou, from the Upper Carboniferous. The authors consider that various species from the Alpine Trias referred to *Retzia* by Bittner, are closely related to this genus.

PARAZYGA (*Atrypa* or *Trematospira hirsuta*), Hall.

ANABIA, type *Anabia Paraia*, Clarke.

CYCLOSPIRA, type *Orthis bisulcata*, Emmons. It is "closely allied by external form to *Dayia navicula*, but differs so widely in internal structure that the two species appear to be but remotely related to each other."

PROTOZYGA, type *Atrypa exigua*, of which the *Zygospira aquila*, Sardison, and *Hallina Nicolleti*, W. and S., are synonyms.

CATAZYGA is a subgenus founded on *Athyris Headi*, Billings, and in CLINTONELLA we have a genus based on a new species, *C. vagabonda*, from the Clinton group.

ATRYPINA, type *Leptocœlia imbricata*, Hall, from the Lower Helderberg series, is an interesting genus including several small Atrypoids which foreshadow the *Atrypas* of the reticulated type of *A. reticularis*, to which the American palæontologists would restrict that generic appellation. These seem to have been "not derivatives of the yoked spire-bearers *Zygospira* or *Catazyga*, but to have developed in a line essentially parallel with those genera," and to have originated from a common ancestor (p. 111).

Hence it is evident the authors suggest some interesting points for discussion, and throw further light on the evolution of the Brachiopoda by their careful studies of the spire-bearing group from the ancient rocks of America. The completion of their researches on the Rhynchonelloids and early Terebratuloids will be awaited with interest by all students of the Brachiopoda, who cannot fail to recognize the value of Professors Hall and Clarke's laborious, painstaking, and most fruitful researches.

AGNES CRANE.

III.—THE GEOLOGY OF THE SOUTHERN TRANSVAAL. By W. H. PENNING, F.G.S., etc. 8vo. pp. 37. E. Stanford (London, 1893).

THIS memoir has been prepared to accompany Mr. Penning's Geological Map of the Transvaal Goldfields, published by E. Stanford, and based on the author's researches, as given in detail in several papers in the Journ. Soc. Arts and Quart. Journ. Geol. Soc. in 1884–91. It unites the four gold-bearing localities, the De-Kaap and Lydenburg, the Rand and Klerksdorp, an area about 450 miles long, by 50 in breadth, comprising some 22,500 square miles. This

has been geologically coloured, as correctly as circumstances have permitted, on an existing map; and it appears to carry out the author's views (1) that the main gold-bearing rocks are siliceous deposits laid down as sandstones and conglomerates in water of some sort; (2) that, though folded in some places, they dip regularly downwards, at least near Johannesburg, and then for about 150 miles they at first strike E., dipping S., then S.E., dipping S.W., then S., dipping W., and then westwardly with a northerly dip, to form one rim of the basin of which the northern rim is the Witwatersrand; (3) that the beds are thus continuous underground from rim to rim, some series of beds varying in their persistency, and thus differing in their gold-bearing qualities; (4) that gold was deposited chemically from the water which moved and deposited the pebbles mainly constituting the "bankets." The thickness of the Witwatersrand beds near Johannesburg (the lower part of the series) is estimated at about 17,000 feet; and, the outcrops being known in some cases, and the underground position and lie of the beds in others, calculations can be made as to the probable extension and depth of the beds in the several mines and borings.

Other features besides the "bankets" are succinctly treated of, with a personal knowledge of the geography and geology, the chief rivers, valleys, plateaux, and mountains being mentioned. Of the geological formations occurring in the Southern Transvaal, besides (1) Recent Alluvium, (2) the River-gravels of the present streams, and (3) those of the older valley-systems, the following are indicated on the Map, in downward succession: (4) the High-Veldt Beds, in the lower part of which are coal-seams of some value exposed in the valleys; (5) the Kimberley Beds; (6) Bedded felspathic Trap-rocks; (7) Upper Witwatersrand Beds; (8) ? Bedded felspathic Trap-rocks; (9) Lower Witwatersrand Beds, or "Banket" formation; (10) De-Kaap Valley[1] Beds; (11) Granite and Granitic Rocks.

The De-Kaap rocks near Barberton, at 8 sections, are first described; the Lower Witwatersrand rocks at 29 sections, those of the Upper series at 11 sections; and others are referred to. The much faulted area of the Lower series at Leopard's Vlei is shown by a plan at page 21. A separate plan of the Witwatersrand Goldfield, on a scale of 10 miles to $1\frac{1}{2}$ inches, is given on the Map.

The thick limestone (dolomite?) into which the Mooi River burrows at Wonderfontein seems to be included in the Upper Witwatersrand series, and some particulars of its character and range would have been of interest to geologists.

The Kimberley Beds and the coal-bearing beds of the High-Veldt formation are briefly noticed, with accounts of two sections (Boksburg and Brakpan), and reference to former papers on the subject. Some remarks on the well-known great denudation of the country and its alluvial deposits are appended.

[1] The Valley of the De-Kaap River is here intended; and that better name is retained by the author once, at page 26, as in the Quart. Journ. Geol. Soc. vol. xli. 1885, pp. 569, etc., and vol. xlvii. 1891, pp. 451, etc., pl. 15.

Mr. Penning's map here noticed, and its explanatory brochure, are welcome additions to our knowledge of the Geology of South Africa.

Note.—It may be added that the output of gold from the Witwatersrand mines was stated by the Chamber of Mines at Johannesburg to have been in May, 1893, 116,911 oz. 15 dwts., valued at £411,877 (at about £3 10s. an ounce); in June the output was 122,907 oz.; in July 126,169 oz.; and in August 136,069 oz., valued at £476,319.

IV.—Monographs and Bulletins of the United States Geological Survey.

ANOTHER batch of these most useful and valuable publications has just reached this country.

Monograph xvii., "The Flora of the Dakota Group," is a posthumous work of Leo Lesquereux, edited by F. H. Knowlton, who, in his preface, gives some interesting details in the life of the author. The work was undergoing final revision by Lesquereux when he died, and it has been yet further amplified by the editor, thus making it the most complete monograph on the subject, and rendering the Flora of this group one of the most thoroughly known to palæobotanists.

Monograph xviii., "Gasteropoda and Cephalopoda of the Raritan Clays and Greensand Marls of New Jersey," by R. P. Whitfield, is a second contribution to the palæontological knowledge of these beds, the Brachiopoda and Lamellibranchiata having formed the subject of Monograph ix. (1885). The material dealt with proved very unsatisfactory, consisting largely of casts, which render the determination, even of genera, most difficult, and though no pains were spared by the author his task is not yet completed, and it is to be hoped that in future he will meet both with better material and a better artist, for, with the exception of certain of the Cephalopod plates, the drawings are decidedly flat.

Monograph xix., "Geology of the Eureka District, Nevada," with an Atlas, by G. A. Hague, includes a special paper on the "Microscopical Petrography of the Eruptive Rocks of the Eureka District," by J. P. Iddings, and a "Systematic List of fossils of each formation in the Eureka District," by C. D. Walcott. The Palæontology of the district was treated of in Monog. viii. by Mr. Walcott, and its Silver-Lead deposits in Monog. vii. by Mr. Curtis. The present work is purely geological, and is a very careful study and survey of a small tract of hitherto unmapped country.

The bulletins to hand include a series of the useful correlation papers: No. 82 Cretaceous, 83 Eocene, 84 Neocene, 85 the Newark system, and 86 Archæan and Algonkian (in which last are included "all recognizable pre-Cambrian clastics, and their equivalent crystallines").

The sole palæontological number is 93, devoted to an account of "Some Insects of special interest from Florissant and other points in the Tertiaries of Colorado and Utah," by S. H. Scudder, who

records the first discovery in America of a fossil Gomphina (*Stenogomphus carletoni*, n.g. et sp.), of a fossil *Cicada* (*C. grandiosa*, n. sp.) of large size, with other new genera and species of fossil Insects, including a bot-fly (*Palæstrus oligocenus*, n.g. et sp.), who, in the absence of the Mammalian families at present most subject to the attack of its descendants, probably devoted its attention to the Tylopoda.

"The Record of North American Geology for 1890" (No. 91), carried out on the same excellent lines as it predecessors, and a "Report of work done in the division of Chemistry and Physics" (No. 90), are the most important of the remaining bulletins; the other subjects being: "The compressibility of Liquids" (No. 92); "The Mechanism of solid Viscosity" (No. 94); "Earthquakes in California in 1890 and 1891" (No. 95); "The Volume Thermodynamics of Liquids" (No. 96).

V.—Palæospongiologie. Von Hermann Rauff. Erster Theil. 1te—4te Lieferung. Mit 48 Abbildungen. Palæontographica, Bd. XL, 1893, pp. 1–232. Stuttgart.

THROUGH the efforts of numerous authors within the last twenty years to amend the description and classification of fossil Sponges, the discredited position which this group sustained for such a long time previously has now been to a great extent redeemed, and it may be said to-day that our knowledge of the fossil, as compared with that of the recent forms, is quite on a par with that of any other class of animals. The modern method of study of the fossil forms initiated by von Zittel, not only opened the way for their reconstruction on a natural basis, but it also reacted on the work done amongst the recent forms as well, and supplied important clues to a proper understanding of their nature and relative position. By a fortunate coincidence this new work on fossil sponges took place at a time when the Challenger and other expeditions brought to light, from great depths of the ocean, a number of living sponges, previously unknown to science, which proved to be related to the groups most numerously represented in cretaceous and other rocks. The description of these recent deep-sea sponges has contributed much fresh knowledge of their characters, and thereby also added to that gained already respecting their fossil relatives, and this, together with the increased amount of recent work amongst the fossil forms, furnishes a wealth of material for a general treatise on these organisms from a palæontological point of view. Such a work, we are glad to report, has been undertaken by Dr. H. Rauff, of Bonn (a former student of Prof. von Zittel), and the first four parts, now before us, which are being issued in the "Palæontographica," show that the subject is being treated in a fuller and more comprehensive manner than has hitherto been attempted.

In the introductory or general part, a chronologically arranged list of papers relating to fossil sponges, to the number of 592 is given, followed by another list containing the author's names in alphabetical order, the titles of their papers, and the particular

geological horizons of the sponges described in them; which will materially facilitate the hunting out of references. Next comes a long chapter on the literature of the group, in which the various views and systems of different authors are explained and discussed. It is somewhat depressing to see from this what a large amount of earnest labour has been wasted, on what we now recognize to be thorough failures to understand the real nature of these organisms, and this groping in the dark lasted to pretty well up to 1876.

Succeeding chapters treat of the Morphology, the Histology (as known from living forms) and the Canal system in fossil sponges, and the author describes nine different modifications of the canal system as shown by the skeleton. The mode of increase is then referred to, and the puzzling question as to what constitutes an individual or a colony. Next comes the important subject of the nature and form of the various kinds of spicules in siliceous and calci-sponges, and the mode of their union in the case of the former of these.

In the classification the author considers the Sponges, as a whole, to belong to the Metazoa rather than to a separate sub-kingdom. Four orders of siliceous sponges are recognized, 'Hexactinellida, Tetractinellida, Monactinellida, and Ceratosa.' This last may be neglected, since no fossil forms belonging to it are as yet known, and of the other three it may be said that palæontologists are mainly concerned with only two groups, the Hexactinellids and the Lithistids, since with rare exceptions, all the forms of fossil siliceous sponges are included in them, though we know from the abundance of the detached spicules of Monactinellids and Geodine Tetractinellids that sponges of these divisions were probably as numerous in the past as at the present day. In one or two points the classification put forward is open to criticism, thus for example, the Placospongidæ, with their dermal crust of globate spicules, quite undistinguishable from those of the Geodine Tetractinellids, are yet reckoned as Monactinellida; and there is much to support the view that most of the other families placed in the tribe Clavulina have a good claim to be considered as modified Tetractinellids.

As regards the Calcisponges, the author ranks all the known forms, fossil and recent—with one exception—under a new order, the Dialytina. The solitary exception is a very remarkable new form from the coast of Japan, at present very briefly described and not yet figured, which Dr. Doderlein states has the spicules connected together in the same way as in the siliceous Lithistids. This new form stands as the only representative of the order Lithonina.

There is one particular feature in this work to which exception may be taken, and that is the excessive use of terms taken from the Greek to designate the various forms and parts of spicules. In this matter Dr. Rauff may plead that he has followed the example of some of the principal writers on recent sponges during the last few years, who have agreed to cast aside, with very few exceptions, all the terms previously employed in spongiology and replace them by new Greek ones. To make matters worse, these authorities are not always agreed as to the most suitable Greek words to employ, though

they seem to consider the vernacular unsuitable even for the simplest forms of spicules. As an illustration of the peculiar language current amongst leading spongiologists the following description of a simple spicule is taken from one of the "Challenger" Reports on Sponges:—"Tylotoxea. The esactine of the rhabdus is tylote and the ecactine oxeate." It will hardly be believed then when interpreted into English this sentence only means that the spicule is pin-shaped, having a knob or head at one end and tapering to a point at the other. The true interests of science are hardly likely to be advanced by such a pedantic employment of Greek, but it is a very effectual method of darkening knowledge and restricting it to a very select circle of Illuminati. We do not in the least wish to impute that Dr. Rauff or other authors use the Greek with such a purpose; they will probably allege that only in this way can a scientific nomenclature be obtained.

In conclusion we desire to express our hearty appreciation of the thoroughness and accuracy of Dr. Rauff's work and of the service he is rendering to palæontology; and we anticipate with much interest the appearance of the remaining portions of this Monograph.

CORRESPONDENCE.

CONCENTRIC LAMINATION AMONGST THE PEBBLES ON NORTHAM RIDGE.

SIR,—Owing to an insufficient index I unfortunately missed Mr. Townshend Hall's paper on the above subject in the "Transactions of the Devonshire Association," vol. iv. p. 433. Mr. Hall maintains that the lamination "has been produced by the effects of the long-continued hammering and pounding which the pebbles have received one from the other." While regretting my oversight, I cannot but rejoice that these curious cases of lamination by pressure in the form of percussion have been so well attested. A. R. HUNT.

TORQUAY, *Oct. 10th*, 1893.

OBITUARY.

EDWARD CHARLESWORTH, F.G.S.

BORN SEPTEMBER 5TH, 1813. DIED JULY 28TH, 1893.

THERE has lately passed away from the geological ranks one who for many years was a prominent figure at the meetings of the Geological Society and the Geologists' Association.

Edward Charlesworth was born at Clapham, Surrey, on the 5th September, 1813. He was the eldest son of the Rev. John Charlesworth, M.A., rector of St. Mildred's, Bread Street, London, and grandson of the Rev. John Charlesworth, a Fellow of Trinity College, Cambridge, and vicar of Ossington.

Mr. Charlesworth's father was much interested in geology, through the influence of Prof. Lambert, and at an early age he imbibed a strong taste for collecting fossils, which became the ruling passion of his life.

He was educated at a private school by the Rev. W. Kitchin, rector of Nedging and Norton, Suffolk, and father of the present

Dean of Winchester. At an early age he was articled to an eminent London physician and later on entered Guy's Hospital as a student; but, having a distaste for medicine, he abandoned it and turned his attention to scientific subjects, especially to geology.

When only 22 years of age he published a masterly paper "On the Crag-formation and its Organic Remains" (Phil. Mag. vol. vii. 1835, pp. 81–94). He therein pointed out that the Crag of Suffolk was divisible into two parts, which he termed respectively the "Coralline" and the "Red Crag." These divisions were accepted by Lyell, and they have now become permanently established. He subsequently pointed out that the Crag of Norfolk formed a newer division, which he named the "Mammaliferous Crag"; but to this bed the term "Norwich Crag" is now generally applied.

In 1835 Mr. Charlesworth was elected a Fellow of the Geological Society of London, and remained a Fellow up to the time of his death—nearly sixty years.

In the same year (1835) he was elected an Honorary Curator of the Ipswich Museum, where some of his early collections of Crag fossils are still preserved. He read a paper "On the remains of Vertebrate animals found in the Tertiary beds of Norfolk and Suffolk" before the Geological Section of the British Association at Bristol, in 1836, presided over by Prof. Dr. Buckland. In the same year he obtained an appointment on the staff of the British Museum. In 1837 Mr. Charlesworth was appointed an Assistant to the Museum of the Zoological Society of London, in Leicester Square; he also succeeded Loudon as Editor of the "Magazine of Natural History," which he continued to conduct until 1840. At this time he contributed several papers, on the comparative age of Tertiary deposits; on *Voluta Lamberti*; on *Terebratula variabilis*; and on the teeth of *Carcharodon megalodon* from the Crag, etc.

In 1840 he left England to take charge of a young gentleman of fortune and travel with him through Central America. At this time he occupied himself in patenting an "elevator gun," which he believed to be indispensable for the naturalist and explorer abroad, and hoped to see adopted also for the British army. Twenty years later an enterprising American, Mr. Pomeroy Button, of Cheapside, obtained for it, by advertising extensively, an ephemeral success of a few months and a temporary accession of capital to its inventor; but it was of too brief duration to lead on to fortune.

On returning to England Edward Charlesworth was, in 1844, appointed successor to Prof. John Phillips, as Curator to the Yorkshire Philosophical Society's Museum in York, a post which he held until 1858. In 1846 he brought out the "London Geological Journal," which contained most valuable contributions from the leading palæontologists of the day, and occasionally strong and useful critiques on some of their published facts and opinions. This publication was profusely illustrated by plates; but unfortunately it only extended to three numbers and ceased in 1847.

In this MAGAZINE he contributed a valuable paper on the occurrence of flint in the pulp-cavity of a tooth of *Mosasaurus*.

On Mr. Charlesworth's retirement from York, in 1858, he settled for a time in London, and carried on a Natural History and Geological Agency; but his predilection for the Suffolk Crag caused him to spend much of his time in the Orford, Sutton, and Woodbridge districts in search of fossils. In this he was largely aided by his kind friends, Mr. William Colchester, F.G.S., then of Grundisburgh Hall, near Woodbridge, and Mr. Searles V. Wood, F.G.S., and his son Mr. Searles V. Wood, jun. Encouraged and supported by Mr. William Reed, of York, Edward Charlesworth was, for many years, one of the most active buyers of fossils in London; always seeking to secure the best specimens and paying the highest price for them. In fact, he devoted himself almost solely to the purchase of specimens for Mr. Reed and the British Museum; and the "Reed Room" in the York Museum, and the National Collection, both contain numerous evidences of his keen powers as a collector, especially of the fossils of the Crag District. He was the first naturalist to introduce glass-topped boxes into use in museums for the preservation of delicate specimens, and he set up a manufactory of round glass-topped boxes on a large scale. But it must be confessed that he did not succeed as a man of business, owing to the absence of training in early life. Some of his scientific papers are most excellent, and, as a speaker, he was possessed of great fluency and keen powers of argument. He seldom appeared at a scientific meeting in which he did not take part in the discussion, and, if possible, divert it to the Suffolk Crag, the formation of flint, or some other of his pet theories, about which he never grew tired of collecting evidence and challenging inquiry among his brother geologists.

One of his most recent papers was upon flints, and was communicated to the Victoria Institute.

Mr. Charlesworth was greatly interested in the "Oaths Bill"—especially in reference to the swearing of children whose evidence had to be given in Courts of Justice—a practice he was instrumental in getting abolished. He also took an active part in the establishment of the "Society for the Prevention of Cruelty to Children." His sister, Miss M. L. Charlesworth, wrote the story of "Ministering Children," one of the most widely-circulated children's books ever written.

The Royal Society gives a list of 28 papers on scientific subjects, published by Edward Charlesworth; but he printed and circulated at his own expense an immense number of pamphlets on various social and other subjects, and as a correspondent he probably will never be surpassed for the abundance and length of his letters. Referring to his wonderful powers as a speaker, the Rev. William Vernon Harcourt (founder of the British Association) is reported to have said of him ("York Herald," February 7, 1857): "Mr. Charlesworth has shown us that he is not only intimately acquainted with extinct creatures, but that he has a knowledge of, and knows how to influence, the living creation."

He died at his residence at Saffron Walden, after a comparatively short illness, on the 28th July, at the age of eighty years.

H. W.